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Renaissance II: Canadian Creativity and Innovation in the New Millennium

Edited by
Richard I. Doyle

The Butterfly and the Hurricane

The choice of butterfly-like wings cut into an image of our galaxy as the visual representation of the Millennium Conferences theme is explained in part by this quotation. It is also linked to a concept in chaos theory known as the "butterfly effect." Meteorologist Edward Lorenz, who began conducting computer simulations of weather patterns in the 1960s, found that the tiniest change in the position of his variables completely threw off his calculations. He is quoted as saying that *"a butterfly flapping its wings in the Amazon could spawn a hurricane in Texas,"* suggesting that a small action can induce big changes in the world if it takes place early in the process.

"When we link both hemispheres of the brain, we begin to appreciate and understand the endless natural beauty in our universe — from the metamorphosis that brings a butterfly into being to the laws that govern our position in the Milky Way. This is the beginning of possibility."

Millennium Conferences on Creativity in the Arts and Sciences
1999–2000

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Renaissance II: Canadian Creativity and Innovation in the New Millennium

Edited by Richard I. Doyle

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"To create or not to create is not a question. We Canadians will continue to create because we have done so in the past and have a tradition; but more than that, because we must work together and we must create. We have no choice." —

Dr. Peter Hackett
Program Chair
Millennium Conferences on
Creativity in the Arts and Sciences

Preface

The material presented here has been collected in the context of the Millennium Conferences on Creativity in the Arts and Sciences, a series of events staged in 1999 and 2000 to help Canada mark the arrival of the new Millennium.

Some events were focused entirely on the themes of creativity, innovation, and collaboration between the arts and sciences. In other cases, individual speakers or projects were supported and presented within broader initiatives or conferences as being associated with the Millennium Conferences series.

The following pages include selected speeches as they were delivered at events such as the centrepiece conference Creativity 2000 (Appendix III), papers written to report on such events, notably the Symposium on Creativity and Innovation (Appendix I), biographical sketches, background information, quotes, and stories related to the Millennium conferences and its themes (Appendix II).

Many divergent points of view and perspectives are reflected here. However, each is a reminder of the power that lies in our imagination, our capacity to work together, our ability to learn and grow, and our humanity.

We believe that this material will help you prepare for work, play, and life in the new Millennium.

Acknowledgements

The number of individuals and organizations that contributed to the Millennium Conferences on Creativity in the Arts and Sciences is inspiring testimony to our collective commitment to creativity and innovation and a hopeful sign for the new Millennium.

Only a common desire to collaborate in new approaches toward a vision of a better future could make such an initiative possible.

From the perspective of the National Research Council of Canada (NRC), the Millennium Conferences on Creativity in the Arts and Sciences began early in 1998 with a decision to participate in Canada's Millennium celebrations through a conference series that would augment and challenge its strategies for science, technology, and innovation in the knowledge-based economy with new ideas, new partnerships, and new concepts.

Before progressing very far in its plans, NRC learned that many other national organizations were also looking to magnify their impact and contribution to society through unconventional alliances and projects.

The Humanities and Social Sciences Federation of Canada (HSSFC), for example, was considering an initiative that resulted in the special Symposium on Creativity and Innovation described in the formal Report presented in Appendix I.

Early in 1998 the National Arts Centre of Canada (NAC) was preparing a major conference that explored the role of the artist in the

international human rights movement to commemorate the 50th anniversary of the signing of Universal Declaration of Human Rights, which had been drafted by Canadian John Peters Humphrey.

In the context of this expanded vision, the NAC invited NRC to collaborate in a similar conference that would bring the arts and sciences communities together in a unique forum. NRC saw this invitation as an exceptional opportunity to achieve its Millennium conferences objective.

The founding partnership of the NRC and the NAC soon grew to include the Canada Council for the Arts, the organization known primarily for its role in funding the arts in Canada, but one that has long recognized the importance of science and technology to its community.

Eventually, many of Canada's most innovative national organizations and the world's most creative minds would join the collaboration and make critical contributions to its success.

We have sought to acknowledge them all in the following pages, but know that the many projects and events touched by the Millennium conferences series could not have succeeded without the active involvement and imagination of many more individuals than have been cited here.

We are grateful to them all and particularly to those who attended these events and contributed to their success with their enthusiasm and good wishes.

Sponsors and Supporters of the Millennium Conferences on Creativity in the Arts and Sciences

National Research Council of Canada

National Arts Centre

Canada Council for the Arts

The British Council

Canadian Institutes of Health Research

BCE-Média

Canada Foundation for Innovation

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National Aboriginal Career Symposium

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Canada Council Art Bank

NRC Steacie Institute for Molecular Sciences

NRC Institute for Information Technology

Champions for Children Foundation

University of Brescia (Italy)

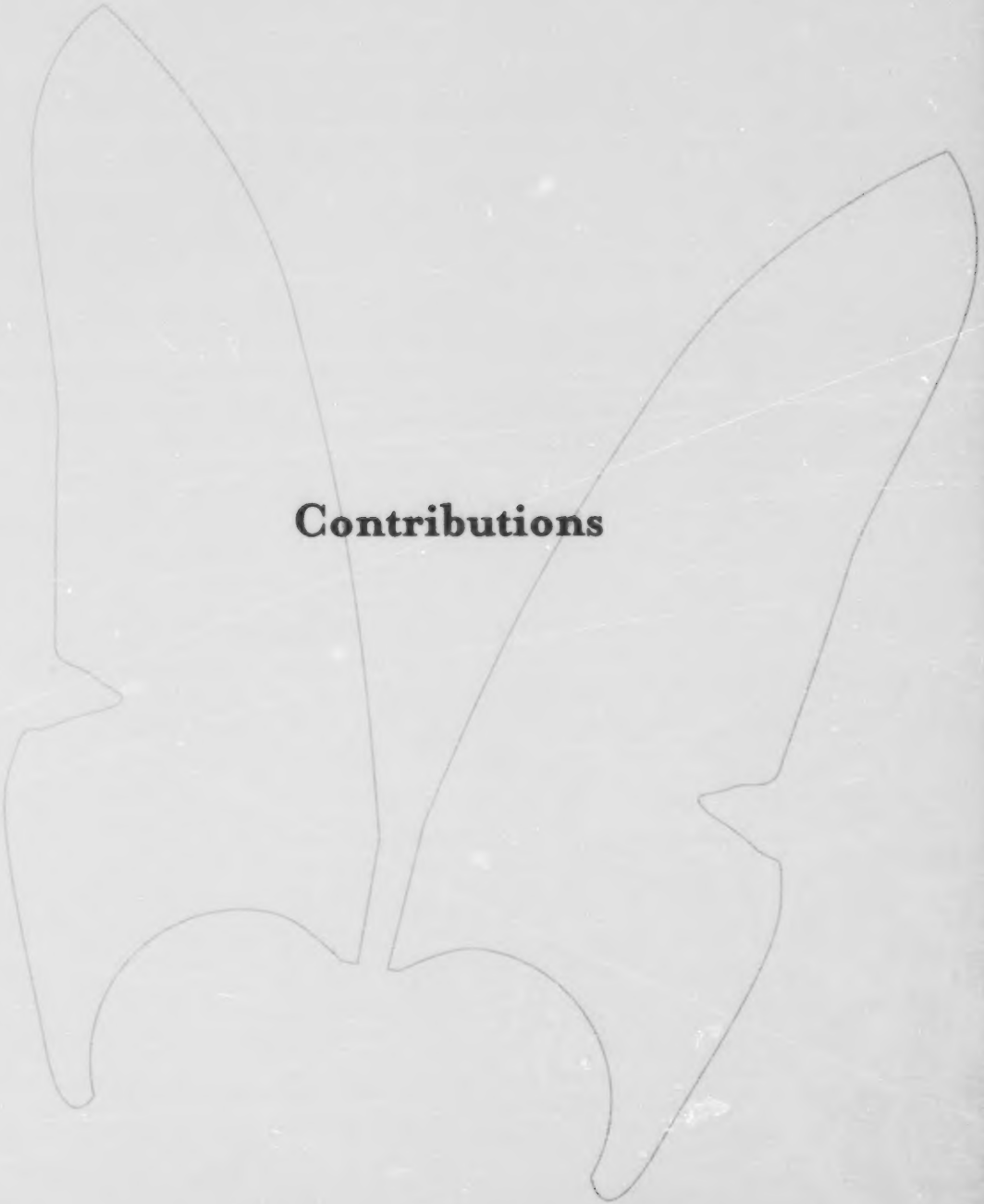
Canada Science and Technology Museum Corporation

Conference on Statistics, Science and Public Policy (Herstmonceux, U.K.)

Inventive Women Project

Silicon Graphics Inc.

The Millennium Bureau of Canada



Contributions

The Governor General of Canada Calls for a New Alliance Between the Arts and Sciences

The Patron of the Millennium Conferences on Creativity in the Arts and Sciences
Her Excellency the Right Honourable Adrienne Clarkson, C.C., C.M.M., C.D.

Born in Hong Kong in 1939, Mme Clarkson came to Canada as a refugee with her family during the war in 1942. She received her early education in the Ottawa public school system and later obtained an Honours B.A. and an M.A. in English Literature from the University of Toronto. She also did post-graduate work at the Sorbonne in France.

Mme Clarkson is fluently bilingual. A leading figure in Canada's cultural life, Mme Clarkson has had a rich and distinguished career in broadcasting, journalism, the arts, and public service. From 1982 to 1987, Mme Clarkson served as the first Agent-General for Ontario in Paris, promoting Ontario's business and cultural interests in France, Italy, and Spain. She was the President and Publisher of McClelland & Stewart from 1987 to 1988. From 1965 to 1982, Mme Clarkson worked as host, writer, and producer of several influential programs on CBC Television, including Take Thirty, Adrienne at Large, and the Fifth Estate. A noted writer, she also contributed numerous articles to major newspapers and magazines in Canada and wrote three books. In 1988, she assumed responsibilities as Executive Producer, Host, and Writer for the programs Adrienne Clarkson's Summer Festival and Adrienne Clarkson Presents for a period of 10 years. She also wrote and directed several films. Her work in television has garnered her dozens of TV awards in Canada and the U.S.

Until the announcement of her appointment as Governor General, Mme Clarkson served as Chairwoman of the Board of Trustees of the Canadian Museum of Civilization in Hull, Quebec, as well as President of the Executive Board of IMZ, the international audio-visual association of music, dance, and cultural programmers, based in Vienna. She was also the Executive Producer and Host of the CBC Television program, Something Special, a Lay Bencher of the Law Society of Upper

"Perhaps it will inspire you to walk down a path which has not been lighted up by others but which you can light for yourselves. That is the meaning of all creation."

Canada as well as Honorary Patron of a number of artistic and charitable organizations.

Mme Clarkson has received numerous prestigious awards both in Canada and abroad in recognition for her outstanding contribution in a variety of endeavours. She was appointed an Officer of the Order of Canada in 1992, holds honorary doctorates from five Canadian universities, and received three honorary academic distinctions.

Mme Clarkson is married to the writer, John Ralston Saul.

In January 2000 the Governor General accepted the invitation to become Patron of the Millennium Conferences on Creativity in the Arts and Sciences. In doing so, Her Excellency lent her general endorsement to the initiative and agreed to be referenced in the capacity of Patron. The following is her address delivered at the opening of Creativity 2000 on Wednesday June 21, 2000.

Her Excellency the Right Honourable Adrienne Clarkson, C.C., C.M.M., C.D.

When I was at university some time ago, one of the streams of thought that was making the most impact on us and causing a debate was the thinking of C.P. Snow as embodied in his series of novels about life in an Oxbridge university in England. By positioning the masters of that college and also in his non-fiction writing, C.P. Snow posited the idea of the two cultures. I remember how seized we were, certainly in a debating way, with the idea that science and the arts were, to use his words, "two cultures."

He said, in his opinion, that they were separated by a "gulf of mutual incomprehension." As they lacked a "common language," scientists and literary people (which happened to be the category of the arts that he chose to focus on, being a writer himself and with a surprising lack of self-interest) were unable to speak to each other.

As I stand here with you today and among you, I can't believe that our twenty-year-old selves at the University of Toronto of that moment in time, in Canada's history, could have believed this to be true or even give it time for discussion. Here I am surrounded by artists, musicians, writers, philosophers, and scientists, and the concept of "two cultures" is hopelessly out of date.

We've been learning more and more about how our brains actually work, we've been able to bring into common parlance the studies of Jung and there now seems to be no gap between the creativity that creates science and the imagination that creates art.

Imagination, perception, intuition are all part of the way in which we now understand how we perceive and act upon the world around us.

In *The Poetics*, Aristotle wrote: *"It is not the business of the poet to tell what has happened, but what might happen and what is possible, according to probability or necessity."* We could so easily substitute the word "scientist" for "poet." And if we did that, we would understand the similarities between these areas of discovery.

For discovery is really what creativity in both the arts and science are about. We're learning now from cognitive scientists that the unconscious plays a significant role in the functioning of the brain as it creates new ideas. I am particularly struck always by the relationship of art to magic, of the act of creation as related to the totally mysterious. Perhaps this has often been downplayed in science, which is frequently perceived to be more objective as opposed to the subjective of creativity in art. But there seems to be no doubt that however we want to phrase it, the idea of inspiration or of the subconscious does play a large role in scientific discovery.

We know that the unconscious or the subconscious have a role in discovery in science. And we have examples where discoveries were preceded by moments of what we would call inspiration. Friedrich Kekulé, the 19th-century German chemist, reaching an impasse studying the structure of the benzene molecule, dozed off in front of a fire. We could ask now, "Why did he doze then? What was the meaning of that?" And then he had a vision of a snake biting its tail and in a flash he realized that the molecular structure was characterized by a ring of carbon atoms. This dream vision directed him towards his future so-called objective research. And there are so many stories akin to this.

The link between scientific discovery and creative activity has been so well established, I think, especially over the last twenty-five years, that I need not go on with any more arguments. There is simply no truth in the division between "two cultures" as C.P. Snow spoke of them to such great discussion and relative acclaim forty years ago. Purposes and processes have made the idea of supposed conflict an intellectual exercise useful to debate but not a reality to confront.

All creative people are involved in activity which is so much larger than themselves that it would be difficult for them to even state what that meant to people who have never been involved in that activity. I'm always rather amused and touched to hear both artists and scientists trying to describe to the laymen exactly what it is that they do. The familiar and dreaded question of the inexperienced interviewer "Where do you get your ideas?" is probably only second to the banality of "Tell me what you're like." What drives all creators — scientific and artistic — is passion and obsession. Most people's lives, unfortunately, contain neither or if they do, they are fixed on animal matters rather than spiritual ones.

What is very difficult for people not involved in creative activity to understand is the excitement and the awe-inspiring straining towards perfection which all discovery or creativity leads to. Einstein said that *"the most beautiful thing we can experience is the mysterious. It is the source of all true art and science."* Perhaps that is the truest thing that can be said about the activity of the people who are taking part in this Conference today.

I really want to salute the people organizing this Conference because I think they are honouring

people who refuse to be pigeon-holed and refuse to stay in categories. The world loves to put people into boxes, neatly tied up. But being in a box even tied with the most beautiful ribbon and wrapped with exquisite paper is still a box. And I have been speaking here of the pure act of creativity that breaks barriers and refuses categories.

In the areas where creativity — scientific and artistic — collaborate, there are myriad examples of a synergy which leads to invention and benefit. And benefit, I may add as a footnote, is only a reasonable practical outcome in a society of fruitful collaboration.

I want to recall to you that thirty years ago scientists from around the world were exploring the idea of something called computer animation, and those who were doing so at the National Research Council had the inspiration of working with film makers at the National Film Board of Canada. By seeking the input of people who would actually use their technology, there was an extremely energizing and dramatic collaboration which in retrospect was the one that would actually give Canadians their competitive edge. We, in Canada, were the first in the world to develop computer animation. In 1997 when the scientists — and it was the scientists interestingly enough — received an Academy Award (that is the ceremony that happens the week before the one where everybody thanks their mothers!) for their technological innovation, they credited their collaboration with the film makers in the 1970s for pushing their discoveries.

Today, we really take for granted the idea that artists can use technology to create. Videos, computers, lasers are basic tools. Perhaps the degree to which scientists rely on art is less visible.

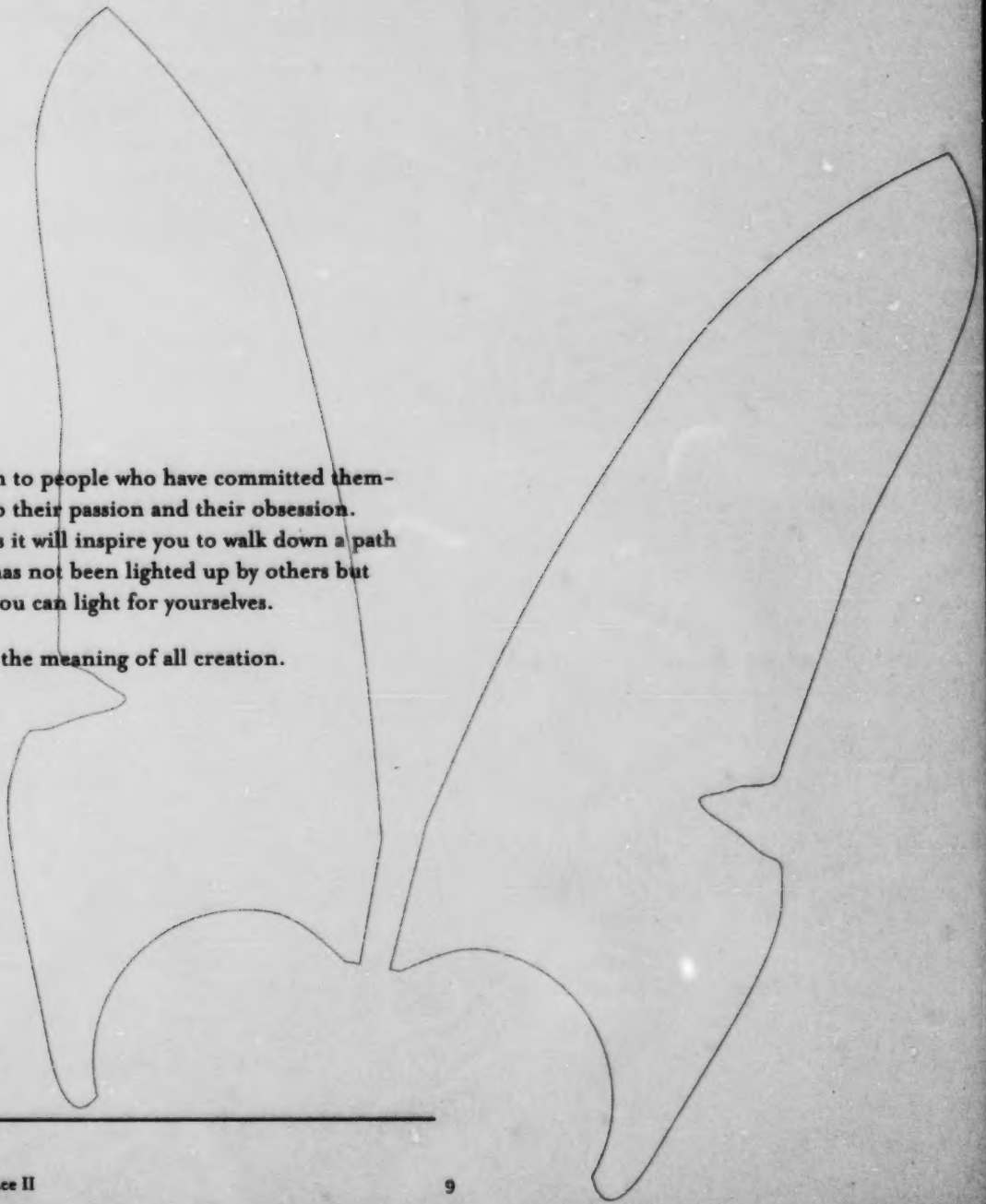
Twenty or thirty years ago, anyone strolling through the halls of the National Research Council could probably readily identify the various labs — metallurgy, biology, chemistry. Today if you did that same walk, you would be hard-pressed to discern what disciplines scientists were actually investigating. So many scientists work in the world of virtual reality, an artist-created environment that actually doesn't exist. A creation actually can bounce off the walls of technology and rebound into the world of science. Computer animation was developed for artistic purposes but now it's a valuable tool in laboratories around the world. And I haven't even begun to deal with its widespread and now essential use in computer-assisted design for such things as architecture.

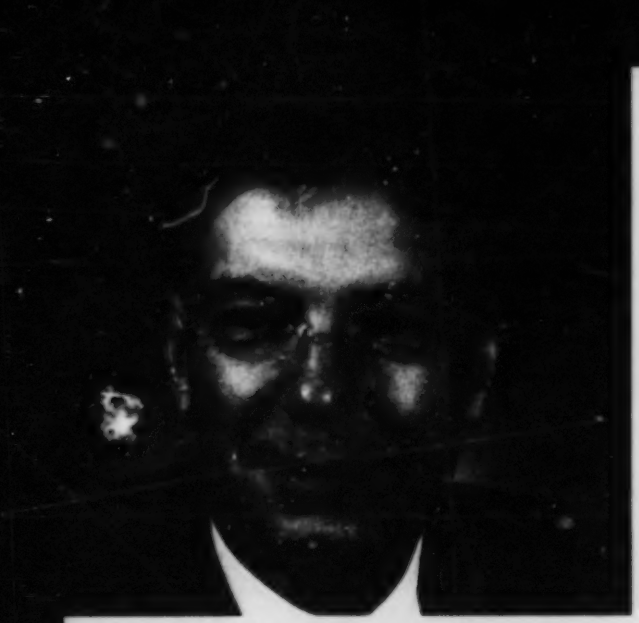
Just six years ago, we designed our cottage with an architect completely through computer-aided design which not only saved us time but gave us a total idea of what it would be like to live in that limited space which we were allotting to ourselves. I thought it was marvellous then and I still do. We were given a dimensional world which we had only been taught how to approach previously by looking at Cubist paintings.

Art always shows us the way to discoveries of perception. And that is also the link between art and scientific discovery. And discovery, whether artistic or scientific, is about that mysterious passage where the voyage is everything and the end is not. I think it's wonderful that there are so many young people in the audience and they are here

to listen to people who have committed themselves to their passion and their obsession. Perhaps it will inspire you to walk down a path which has not been lighted up by others but which you can light for yourselves.

That is the meaning of all creation.





Scientist and Research Manager Says We Need to Learn from Children and Look Beyond Our Place in Time

Program Chair – Creativity 2000
Vice-President (Research)
National Research Council of Canada
Dr. Peter Hackett

Dr. Peter Hackett is an internationally recognized chemical physicist who pioneered many applications of lasers in chemistry. His innovations have earned him the Noranda Lecture Award of the Canadian Society for Chemistry, the Rutherford Medal of the Royal Society of Canada, and other honours.

He pursued his post-secondary studies at the University of Southampton, England, and joined the National Research Council of Canada (NRC) as a post-doctorate fellow in 1972.

In January 1998, he was appointed NRC Vice-President of Research.

As Program Chair of the Millennium Conferences on Creativity in the Arts and Sciences, Dr. Hackett oversaw the development of the conference series and spoke formally at several events including Creativity 2000 in Ottawa and the Symposium on Creativity and Innovation in the Arts and Sciences in Edmonton.

The following is drawn from these speeches.

Dr. Peter Hackett

If the Millennium Conferences on Creativity in the Arts and Sciences produced any broad consensus or overall conclusion, it would be that creativity is without doubt Canada's most significant natural resource — in fact its primary resource.

The ability and capacity of our young people to imagine and create their futures will determine our future as a nation, including how richly we experience that future. We must value creativity and foster it in every conceivable way.

The good news is that to do so not only advances our collective interests but also values our humanity because to create is fundamental, and always has been. Just as Aristotle observed in his Metaphysics that *"All men desire to know,"* I believe that we also share a common desire to create, and this desire has driven our evolution — natural, cultural, and technological.

As discussions at the Millennium Conferences often illustrated, creativity has even made these three evolutionary types impossible to distinguish from one another. Furthermore, the rate of our technological evolution is constantly accelerating; it has now attained a pace that challenges our cultural world and our natural world's ability to cope. The integration is magnified daily.

We must therefore make a shift in our conceptual space to muster the creativity necessary to respond to the challenges before us. We must consider the whole and work together to common purpose. The encouragement of this shift was one objective of the Millennium Conferences on Creativity in the Arts and Sciences.

Rather than asking what we should teach our children, we might better ask ourselves what we should learn from them.

Creativity and Our Children

As we consider how to encourage creativity in individuals and future generations, we might rephrase the question.

Rather than asking what we should teach our children, we might better ask ourselves what we should learn from them.

Many of the Millennium Conference participants associated the creative act with childlike wonder and engagement. So before we take too much pride in reviewing the creativity of the professional adults outlined in this document, we should remember the one group that is the most creative on Earth: our children.

In this context, one of my favourite stories comes from the Hawaiian Islands in the mid-1800s, when thousands of workers from a variety of cultures were brought there to work on the great crop plantations. The adults spoke English or Japanese, Mandarin or Fijian or Gaelic, and were mutually unintelligible. But in a single generation, their children had invented and perfected a communal language, easy to learn and use but rich and expressive.

The linguist who documented this said he could no l...ger look at any child without a feeling of awe.

The invention of Hawaiian Pidgin illustrates that creativity uses a process that is innate to all of Earth's brainier creatures, including us — or at least to their young.

That process is play. Play is so central to the creative act that the two are indistinct, possibly identical. Like creativity, play is not merely one of

our traits, even an important one. It is defining. We are who we are; we do what we do, because we play.

Both creativity and play draw upon the power of the imagination, as only the imagination can link constructive activity to unrealized enjoyment and, as in the case of Hawaiian children, to draw upon the best that each of us has to offer when we work together in common purpose.

So as we encourage our children to play and to do so creatively, we are encouraging them to use their imagination to amplify the experience and to love learning and doing.

While imaginative play does not constitute an end in itself, we might increasingly recognize it as an appropriate means of learning, exploring, contributing, and creating.

Creativity and Our Organizations

Even when adults do the inventing, their work involves creative play. Most of the epochal discoveries of science came from adults pursuing something solely for the love of it — because, as some kids would say, it was cool. The usefulness followed later.

This is important to note, as it is now generally accepted that the source of wealth, all kinds of wealth, is a creation that is specifically human: Knowledge. Knowledge applied to things we know how to do leads to productivity.

Knowledge applied to things we have not done before leads to innovation. This news has even reached the August ears of the US Federal Reserve. In June 1999, Alan Greenspan said: *"Something special has happened in the*

American economy in recent years — a remarkable run of economic growth that appears to have its roots in ongoing advances in technology."

Ours really is already a knowledge-based economy. High-tech firms now produce nearly twenty billion dollars per year in goods for export alone, employing more than four hundred thousand Canadians. In both value added and people employed, those figures exceed the most optimistic data for the entire Canadian lumber industry. The New Economy is upon us.

Decades of work by the national institutions, the companies, and the other organizations such as those participating in the Millennium conferences have contributed significantly to the national successes in creativity and innovation that built the new economy and define our quality of life.

How can we apply the notion of play and creativity in building the organizations of the future? I believe that while every great organization has its own special qualities, all are driven by two great ideas: one of creativity and another of structure. This creates a kind of tension.

Creativity flowing from bright and energetic people engaged in play is exemplified by the life of Dr. Gerhard Herzberg. The tension results from our belief that we can manage creative energy toward specific, common goals.

At the National Research Council of Canada, we see creativity as essential to our success as a research organization. It's our mission statement; it's what we do. Because of this, we have always recognized that creativity is the lifeblood of discovery, and of the innovations that flow from discovery.

Our structure, our common goal is the interest of Canada and our vision as a valued national organization. We aspire to encourage play and to manage it within the structure of a compelling vision, our collective imagination, of where we fit as an organization within Canada.

Our success as an organization lies in our capacity to set our employees free to be creative, to be their very best, and to work with others while keeping the vision of a better Canada in mind at all times.

Through the Millennium Conferences, I learned that similar combinations of creative play and tension come into play in the artistic world where the tension of discipline and technique combine with the imagination and vision to produce wonders.

Clearly, we must balance and blend these forces within our organizations and ourselves to spawn creativity.

Creativity and Our Nation

As our country and the countries of the world enter the new Millennium, they will also need to promote visions that encourage creativity, but they will need to be even more reflective, more social, more long-term than in the past.

National prosperity, though it demands all the creativity we can bring to it, is not the only challenge we face. Many other issues are as great, and we must embrace all interests and resources to realize creative solutions.

Some of our problems are local; some are global; some are both. Some regions of the world, for

example, seem to be sliding into social implosion: a kind of tribalism with advanced weapons. In many regions, deforestation, drought, and other resource depletion create first poverty, then starvation, then conflict over what resources remain. At the same time, diseases escape their natural reservoirs and become pandemics that can quickly move from continental to global. In addition, technology is not a panacea. Along with its many solutions come some pressing problems.

The sheer quantity of humanity, its growing mass, is putting intolerable strain on food and energy supplies. Land, lakes, and seas are becoming cesspools. Our current state of industrialization pours poisons into the biosphere, killing whole genera and stunting normal human development. Greenhouse gases warm the Earth.

When the connected world finally has a collective intelligence, everything will change — taxes, laws and regulations, culture, knowledge, the nature of nations, and the nature of economies: everything. Yet even at the threshold of this profound and permanent revolution, it will be impossible for any one of us to have all knowledge. Indeed, it is impossible now. What should everyone know? This question demands our collective knowledge and creativity.

In the past, new solutions almost always involved new knowledge.

Tomorrow, many solutions will arise when the imagination of some creative person links existing knowledge in new ways. This will require our separate disciplines to mix more.

As nations, we must help artist to speak with scientist, scientist with laborer and poet, the businessperson with all. It is time for scientists to give full value and respect to a new perspective —

modifying the reductionism of the scientific method, and integrating the perspective of the social sciences and humanities.

The pace of change and the omnipresence of our technologies challenge us. We must respond by working on the human factors. As we do this work, we must also understand that since 'the right tool is half the job,' every creative solution is another right tool. For creativity, while often fun, is also deadly serious.

Our play is not without risk, and never has been. Nothing can be risk-free that has so much potential to change us and our world.

But it is all we can do, for 'To create or not to create' is not a question.

We Canadians will continue to create because we have done so in the past, and have a tradition; but more than that, because we must work together and we must create. We have no choice.

I believe Canada is up to the challenge because I believe that we have shown the ability to imagine and create such a future in the spirit of George Bernard Shaw's often quoted remark: *"You see things that are and ask why; I dream of things that never were and say why not."*

We create what we dream, especially when we do so together.

So if the imagination of children can encourage them to play creatively and if an organization's vision of its place within a nation can provide a context for creativity and innovation, perhaps a nation's collective imagination — its vision for itself as force among the nations of the world — can foster creativity among its citizenry.

What Canada's national vision should be will be for others to define.

Certainly, it should be inclusive, encourage us each to learn and aspire to best we can be, and foster creativity.

Sir John Maddox, the long-time Editor of *Nature*, scientist, and distinguished author, spoke at two of our Millennium Conferences events.

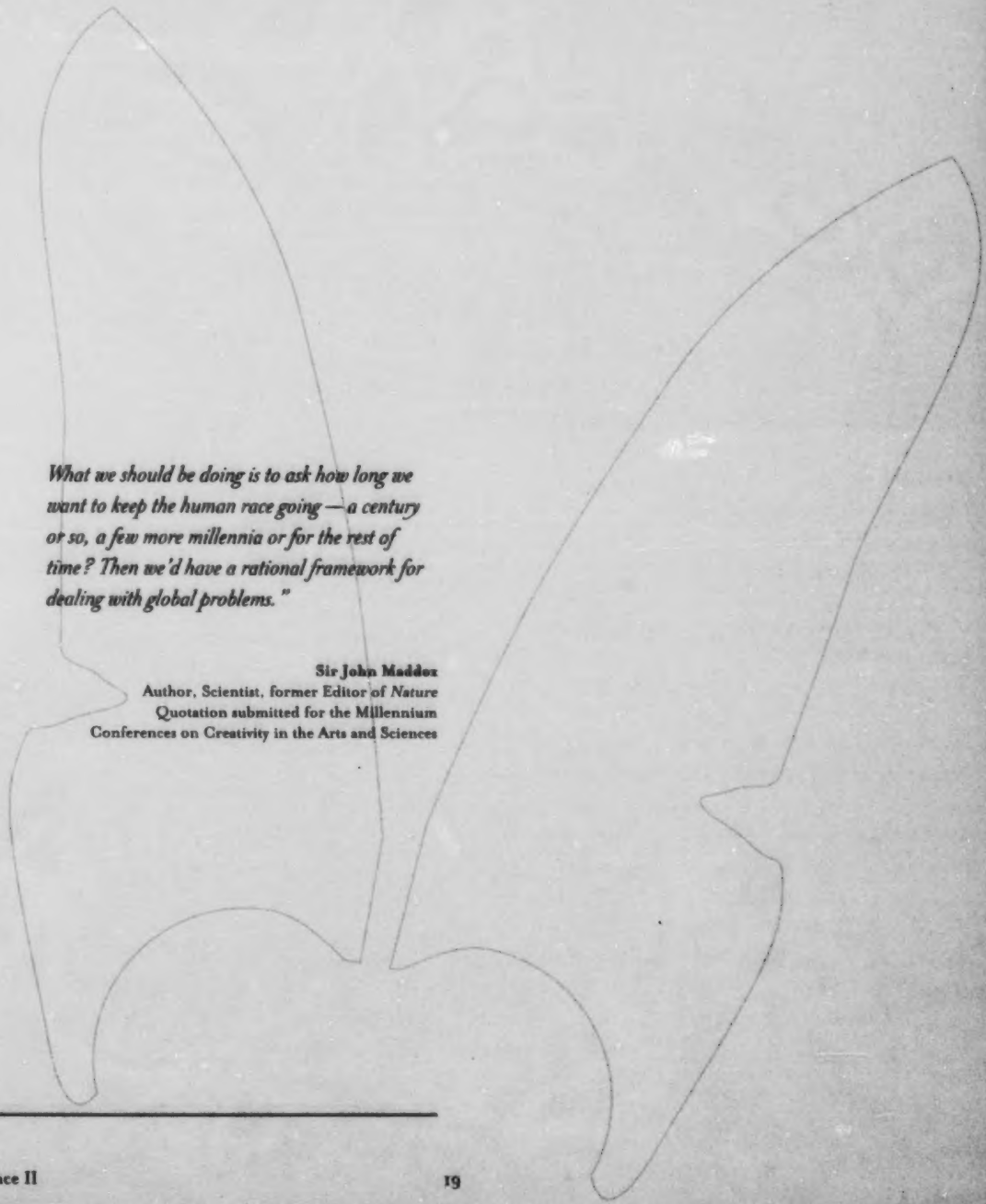
He suggests that the seed of such a vision lies in a focus that is longer term than many nations are accustomed to considering.

Perhaps the best way for a nation to encourage creativity within its own borders is to adopt a vision that looks beyond its own borders, its own interests, and even its own place in time.

"Current global problems all have their roots in the way in which the human race has opted out of natural selection.

For 10,000 years, we've built shelters against the weather and have industrialised agriculture so as to avoid the hazards of hunting and gathering; now, for the best of reasons, we offer sickly children paediatric medicine to avoid their untimely death.

In this artificial world, the human population grows without restraint and our emissions of carbon dioxide threaten to change the climate — and we are irrationally surprised. Some people even suppose that we can preserve our comfortable way of life and at the same time preserve all the other species on the surface of the Earth in their present condition. That's like asking that water should run uphill.



What we should be doing is to ask how long we want to keep the human race going — a century or so, a few more millennia or for the rest of time? Then we'd have a rational framework for dealing with global problems."

Sir John Maddox
Author, Scientist, former Editor of *Nature*
Quotation submitted for the Millennium
Conferences on Creativity in the Arts and Sciences

Science and Engineering Research Leader Tells How Creativity Applies to Science

President
Natural Sciences and Engineering Research Council of Canada
Dr. Tom Brzustowski

Dr. Brzustowski graduated with a B.A.Sc. in Engineering Physics from the University of Toronto in 1958, and a Ph.D. in Aeronautical Engineering from Princeton in 1963.

He was a professor in the Department of Mechanical Engineering at the University of Waterloo from 1962 to 1987, teaching and carrying out research in thermodynamics and combustion. He served as Chairman of Mechanical Engineering from 1967 to 1970 and as Vice-President, Academic of the university from 1975 to 1987. After that he served as deputy minister in the Government of Ontario from 1987 to 1995, first in the Ministry of Colleges and Universities, and later in the Premier's Council.

Tom Brzustowski was appointed President of NSERC in October, 1995. Dr. Brzustowski holds honorary doctorates from the University of Guelph, Ryerson Polytechnic University, and the University of Waterloo, and has received the Engineering Alumni Medal of the University of Toronto.

The following is his address to the Creativity and the World Banquet held at the National Arts Centre (NAC) on June 20, 2000, on the eve of the Creativity 2000 conference.

Dr. Tom Brzustowski

It is my very great pleasure to offer some words of welcome at this important event, Creativity 2000, one of the Millennium Conferences on Creativity in the Arts and Sciences. There is no better way to anticipate the value of what might be achieved here than to note the names of the eminent people who have agreed to participate in the program.

This is a wonderful initiative, itself very creative, and I wish to congratulate the National Research Council, the National Arts Centre, and the Canada Council for the Arts for having organized it. NSERC is very pleased to join with them to help sponsor the activities unfolding here.

As many in the audience might know, NSERC is the Natural Sciences and Engineering Research Council of Canada. We are the agency of the Government of Canada that supports research in the natural sciences and in engineering in Canadian universities, an activity that produces what I consider to be some of Canada's most important creative intellectual work.

When I started thinking about saying a few words of welcome to this conference, I decided to find out just exactly what the word "creativity" meant and in what way it applied to science — if I was to welcome people, I needed to understand the promise of the event. It occurred to me that "creativity" might be a word like "innovation" that has a very diffuse range of popular usage, but also a narrow technical meaning that can get you into problems with some audiences.

(People can get very offended if they think they are labeled not innovative, even if they are not engaged in the activity that the economists call innovation. Might there be some similar reaction to creativity?)

I started off with a dictionary, of course (*Canadian Oxford*), and then moved on to some sources that have been valuable in the past.

What I found were these meanings for two key words:

create: 1. cause to exist; make (something) new or original.....from which:

creative: 1. of or involving the skilful and imaginative use of something to produce e.g.: a work of art, 2. able to create things, usu. in an imaginative way, 3. Inventive

imagination: 1.a. A mental faculty forming images or concepts of external objects not present to the senses, b. the action or process of imagining or forming such images, 2. the ability of the mind to be creative or resourceful ..... which included the point of departure of one of those great circle tours through the dictionary. "Inventive" would take us on another.

These definitions underlined the intimate connection between creativity and imagination, in language that made creativity very obvious in the arts, but not so obvious in science. And yet my intuition insisted otherwise — I felt that creativity and science were strongly linked, and so I went looking for the connection between science and imagination.

I was not encouraged by what I first found in two books by an author whose scholarship and erudition I find awesome, one of my heroes, Daniel Boorstin. I thumbed through my well-worn copies of *The Discoverers* and *The Creators* and found that there were no scientists discussed in *The Creators*. Science was discussed in *The Discoverers*, and that made immediate sense, of course, since the object of basic research is precisely discovery.

My intuition started to waver.

Things didn't get any better when I turned to Daedulus, the Journal of the American Academy of Arts and Sciences.

The Winter 1998 issue, entitled *Science in Culture* carries an article by Lorraine Daston with the devastating title, "Fear and Loathing of the Imagination in Science." The paper itself is less worrisome, as the author states that *"My aim here is not to show that first-rate science requires imagination; others have already pleaded this point with vigor and eloquence. Rather, I would like to explore how and why large portions of the educated public — and many working scientists — came to think otherwise, systematically opposing imagination to science."*

According to Daston, the critical period for this view was the mid-nineteenth century. The issue seemed to be that imagination might somehow undermine the rock-solid structure of the scientific fact, that people might imagine some idiosyncratic description of nature, bend their observations to fit in with it, and proclaim them

as "facts." This was not an issue of the right balance, as no positive effect of imagination on science seemed to be considered.

I find an interesting asymmetry in this concern. People were worried about imagination polluting science, but nobody seemed concerned about science polluting imagination. I have never heard the criticism that science fiction was being undermined by too much science creeping into the writing. Indeed, Jules Verne was the contemporary of some very active voices in the nineteenth-century debate about science and imagination.

But, today, at the dawn of the twenty-first century, debate about the room for imagination in science seems largely to have died down. I believe this has happened because the scientific community accepts findings as fact only through a very open, slow, and careful process, whose principal instrument is international peer review. The process involves many replications of the sequence of events: hypothesis, design and performance of an experiment, documentation of results, error analysis, improved experimental design, etc. At some point, if the sequence is clearly converging, the scientific community will declare the finding to be fact.

The critic might shout, "What about cold fusion?" but that just makes my point. The scientific community followed its processes of independent replication and peer review, and ultimately refused to accept cold fusion as fact, thus

"Creativity in scientific research is seeing what others have not seen, and making it visible to others."

demonstrating that it is perfectly capable of preventing imagination from undermining the base of scientific facts.

At this point, my intuition breathed a sigh of relief. There is no reason today to deny the link between imagination and science. But conscience nagged. Intuition still had to show that a link existed, and that it was constructive. The way to do that leapt out of the title that Daniel Boorstin gave to Part IX of *The Discoverers*: "Seeing the Invisible."

These words, I think, reveal the key to understanding the relationship between creativity in science.

I believe that creativity in science is concentrated in research, and I would hazard to define it this way:

Creativity in scientific research is seeing what others have not seen, and making it visible to others.

On reflection, that definition of creativity might work in the arts as well, if seeing is taken as the metaphor for all the senses and if it includes feeling as well. Michelangelo saw David in that great block of marble, and knew how to remove only what was hiding him from us. Monet's genius was to capture permanently on canvas for us to see forever, the instant patterns of shape, light, shade, and colour that only he could see at the time. Writers of fiction make the constructs of their imagination visible to us in the written word. Composers turn the sounds they imagine into written music that performers can read, and

then conductors and players transform notes that most of us can't read into sounds that move us.

In science, seeing in the metaphorical sense is very important.

Scientific research reveals new relationships — correlations to start with, then eventually causal links as well. Science provides new descriptions of nature that we must see with our minds more than our eyes: Einstein's curved four-dimensional space–time to portray the action of gravity is an obvious example. For another, the chemist Kekulé dreamt of a serpent eating its tail, and made us see the invisibly small benzene molecule as a ring structure. Many famous conjectures in mathematics, that ultimately turned out to be enormously important, were accessible statements of results that were imagined long before they could be proved.

But seeing in the physical sense is, and always has been, a very important outcome of scientific research. Three centuries ago science gave us the telescope and the microscope.

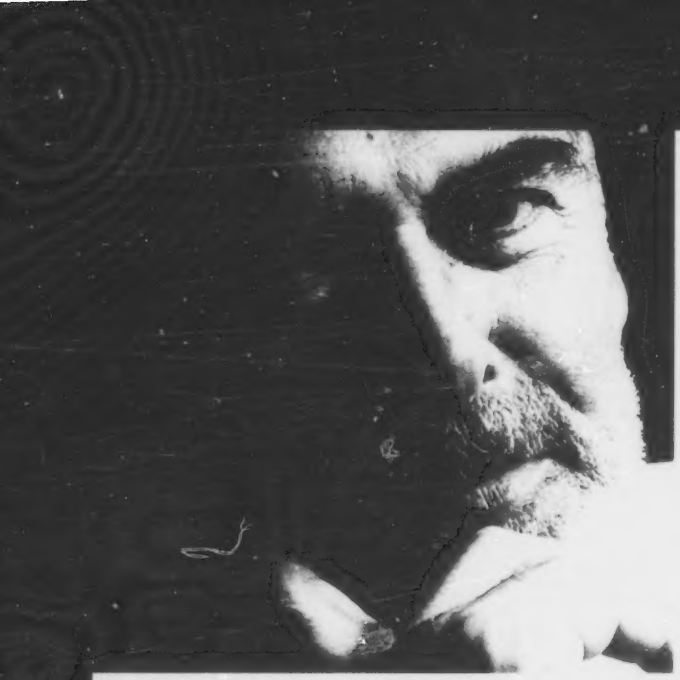
Over the last three decades, it gave us the CAT scanner and the MRI machine, so important for seeing within ourselves; views of the outer reaches of the universe — and thus some of its earliest moments — showing not only the images of distant galaxies but also their velocity away from us; atomic force microscopes that reveal atoms lined up in crystals; multi-hued visualizations of the pressure exerted by air flowing past a high-speed aircraft that is easily modified because it exists

only as a mathematical construct in a computer; and many other images that are often as striking in their beauty as they are in importance.

So there, that's settled. I have managed to reassure myself that imagination and creativity are very important in science. That justifies my words of welcome.

Now, I can eat my dinner with a clear conscience, and later sit back with my intuition intact and learn from another of my heroes, John Maddox.

Thank you.



National Arts Centre Head Says Artistic Capacity Will Impact on Knowledge-Based Economy

Director General and CEO
National Arts Centre Canada (NAC)
Peter Herrndorf

Peter Herrndorf has had an illustrious career in broadcasting and the arts in Canada.

He is the former Chairman and CEO of TVOntario, and served as Vice President and General Manager of CBC's English Radio and Television networks in the early 1980's.

He is also the Founding President of the Governor General's Performing Arts Awards Foundation; the past Chairman of the Board of the Canadian Museum of Civilization; the past Chairman of the Board of The Canadian Stage Company in Toronto; the past Chairman of the Stratford Shakespearean Festival Board of Governors; and the founding President of the Toronto Arts Awards Foundation. In the fall of 1995, the Prime Minister appointed him to a three-member Mandate Review to review the mandates of the National Film Board, Telefilm, and the Canadian Broadcasting Corporation.

A recipient of numerous awards and honours, Peter Herrndorf received an honorary Doctor of Laws degree from York University in 1989 and from the University of Winnipeg in 1993. In 1998, Mr. Herrndorf was awarded the John Drainie Award by the Academy of Canadian Cinema and Television for his distinguished lifetime contribution to broadcasting. In 1999, he was chosen as a lifetime "fellow" of the Ontario Teachers Federation for his contribution to the educational life of the Province of Ontario while he was at TVOntario, and was named as a "Distinguished Educator for 1999" by the Ontario Institute for Studies in Education (OISE).

Appointed in 1993 as an Officer of the Order of Canada, Peter Herrndorf was the first recipient of the William Kilbourn Award presented by the Toronto Arts Awards Foundation for lifetime contribution to the arts in Toronto in 1995. In June 2000,

Mr. Herrndorf was awarded the Diplôme d'honneur by the Canadian Conference of the Arts (CCA).

An active supporter of the Millennium Conferences on Creativity in the Arts and Sciences, Mr. Herrndorf spoke in support of new alliances between the arts and sciences communities on many occasions in 1999 and 2000. The following are his remarks at Creativity 2000, which include an opening address and an introduction to the afternoon session entitled "Reconfigurations: Structure and Space" as well as comments made by some of the participants in these sessions.

Peter Herrndorf

Opening Remarks

We're very proud to work with the National Research Council and the Canada Council for the Arts to bring together so many people with a passion for the arts and sciences. We're proud that the NAC has been chosen as the venue

Why here?

Why not gather across the canal at the Congress Centre to discuss creativity? Or across the street at the Chateau Laurier ballroom?

This afternoon, I'm going to have an opportunity to talk about the science of why this is such a great place for us to gather.

But right now, let me get mystical about why we're here.

On this stage, the finest dancers of our times have performed. As you listen to the sound of my voice and my words, think about other voices and other words heard in this theatre — the greatest actors expressing the most subtle and profound thoughts from the greatest dramas of not just our time, not just the past hundred years, and not just the past millennium — the finest theatre going right back to the Ancient Greeks. If a space can be infused with spirit — if there are « vibes » that linger when the physical presence is gone — then this is a very powerful place. Combine it with the Studio Theatre next door, and the Southam Hall at the other end of the building.

In the 30 years since it opened, these spaces have had perhaps the highest ratio of talent-per-square-inch of any space in all of Canada.

And now that you're all here, the ratio has just gone up!

The National Arts Centre believes passionately in what we have come to discuss today. We believe there is a community of interest among everyone who enjoys the adventure, the exploration, and the fun of creativity — whether your means of creative expression is in the sciences or the arts.

We believe the arts and sciences have much in common and we look forward to examining what we have in common today.

And we believe that Canada's future, in a knowledge-based economy, will be shaped by creativity and innovation. The arts stimulate the brain's synapses.

They get us thinking about things in new ways. The artistic capacity of a nation will have a direct impact on its ability to compete in this knowledge-based economy. For that reason alone — and there are many other reasons as well, I assure — but for that reason alone, Canada's public policy makers must champion the arts and sciences.

It's my pleasure, now, to introduce one such champion.

The Honourable Herb Gray has served in Parliament longer than any sitting member.

He has had a stellar political career since he was first elected to the House of Commons in 1962, and serves as the Member for Windsor West. He has served in ten Cabinet portfolios, as well as Leader of the Official Opposition, and is now Deputy Prime Minister. Prime Minister Chrétien also gave him responsibilities for the Millennium Bureau of Canada. Mr. Gray has come to the NAC many times to enjoy the performances here. Minister, I know that your tastes in the arts are very eclectic. I know that you're a great fan, for example, of Bruce Springsteen, who performed at the NAC back in the 70s.

You could probably tell this audience, even better than I could, about the range of talent that has graced this stage. It's an honour to have you bring us greetings from the Government of Canada.

> *"It is the federal government's view that not only must we make wise investments across the entire spectrum of disciplines in fields of knowledge, in both the physical and social sciences, but just as critical is the creation and maintenance of the links between them."*
>
> **Honourable Herb Gray, P.C., M.P.**
> **Deputy Prime Minister of Canada**

Reconfigurations: Structure and Space

Welcome back from the break. We've enjoyed a very stimulating discussion this afternoon about how the brain creates.

"The arts stimulate the brain's synapses. They get us thinking about things in new ways."

Now we move into a discussion about structure and space.

Let's start by listening to space: listening to how structure affects sound. I want you to stop listening to what I'm saying for a moment, and listen to the sound of my voice. Listen to how it reverberates in this theatre. Listen to how it fades.

I am demonstrating theatre acoustics — a field that fascinates architects and actors, physicists and sound technicians. A room is a musical instrument. It resonates with the sound within it. It adds quality and tone to the sound.

People interested in acoustics speak in terms of diffusion, intimacy, spaciousness, and bass ratio — qualities that affect what kind of art can be performed in a particular space. Music has evolved in response to the sound qualities of the space in which it is performed.

Gregorian chant was performed in stone cathedrals with soaring ceilings, where sounds take five to ten seconds to fade away. The music suitable for that kind of space is slow and dreamy, full of open vowels.

Hundreds of years later, music was written to be performed in small rooms, with plaster walls, where it took sound only one-and-a-half seconds to fade. Composers like Bach and Vivaldi wrote music full of intricacies and polyphany. It sounds great in small rooms. It doesn't work in cathedrals.

Do composers know the science of sound when they write? Not likely. But they know intuitively

what kind of music works in the rooms in which it will be performed. Did the builders of medieval cathedrals or baroque palaces think about how their buildings affected what could be performed there? Not likely.

But today we do know how the science of space and acoustics affects the art of creating music. Scientists, technicians, and architects still don't have all the answers to what makes great sound in a room, but they're getting closer. This is a 20th-century example of how scientists, engineers, and artists have been collaborating.

But what about the 21st century? Technology is creating entirely new challenges and opportunities for artists and performers, scientists and technicians. In London, Ontario, the NRC has a Virtual Environment Technology Centre. Step inside its theatre, and you may find yourself in the prototype of the car of the future, or the inside of the human heart, or the streets of Renaissance Florence. Now that's a theatre!

Today, the centre is used by designers and engineers. The technology is available to the entertainment industry. What kind of art will evolve to take advantage of the ability to create an entire new reality for anyone who steps inside a theatre? What skills will artists need to master? What features will the designers of the technology need to include? I don't have the answers. We need a dialogue between arts and technology about what is possible; between producers and audience about what is desired.

That kind of discussion constitutes a small part of the topic we will look at in Module 3 of our Creativity Forum.

How do the elements of structure and space influence our thinking? What can human thought do to manipulate structure and space? I'm pleased to introduce a panel of very distinguished individuals who will approach the topic from very different directions.

Sir Harold Kroto won the Nobel Prize for Chemistry in 1996.

His research involved a new class of carbon molecules, C60, known as fullerenes. Earlier in his life, however, he was pulled very strongly toward working with another type of carbon altogether: graphite, also known as pencil lead. He seriously considered a career as a graphic artist. Audiences in his native Britain are very familiar with Sir Harold as a science communicator and film producer whose programs are featured on the BBC.

Sir Harry has strong connections to Ottawa and the National Research Council, where he held a post-doctoral in the mid-60s.

"If you have faith... if you actually believe that you are going to get there, you are going to get there."

"Whatever things you like, three, four, or five things, just do each of those to the best of your ability, and don't give up."

"Even though you may not think that you are particularly good at it, if you really do it as best you can, you will probably be better than someone who could have done it better, but didn't."

Sir Harry Kroto
Nobel Laureate in Chemistry
Creativity 2000

The work of our second panelist is very familiar to Ottawa. I have had the privilege of working with our next panellist when I was Chairman of the Canadian Museum of Civilization.

Douglas J. Cardinal is the architect responsible for that museum, as well as many other outstanding buildings in Canada and around the world. In 1993, his firm was awarded the design commission for the National Museum of the American Indian. His firm pioneered the use of computers in architecture, and remains at the forefront of applying technology.

"We all have this marvelous gift of creativity; we all are magical beings. The problem is that we keep ourselves small by not taking responsibility for the individual power that we all have as creative beings. We operate from fear rather than commitment."

"When you are able to make a commitment and say: 'we are going to do this no matter what,' and you become completely unreasonable, then your visions occur. I almost have to discard reason to make these things happen."

Douglas Cardinal
Architect
Creativity 2000

To facilitate the discussion, we have invited Don McKeller. I have admired Don's work as an actor, writer, and film maker for many years. Most recently, Canadian television audiences have seen him in his second season of *Twitch City* which he also created and co-wrote.

The film community knows his directing work through the feature film, *Last Night*, which won the Prix de la Jeunesse at Cannes in 1998. I urge anyone who enjoys the music of the NAC Orchestra or our Baroque series to see another film in which Mr. McKeller starred and shares writing credits, *The Red Violin*. I now turn things over to Mr. McKeller.

"When it comes to creativity, I don't think that you should underplay resistance to structure. Structures aren't always bad; if I didn't have anything to react against, I wouldn't be able to do my work."

Don McKeller
Film maker
Creativity 2000

Innovative Architect Says We Must Confront Our Fears as Enlightened "Spiritual Warriors"

Architect
Douglas Cardinal

Douglas J. Cardinal began practising architecture in Edmonton in 1964. In January of 1976 he incorporated under the name of Douglas J. Cardinal Architect Limited. Since its inception, the firm has undertaken projects of a diverse nature — from individual houses to institutional and governmental projects to twenty-five year community development plans.

Douglas Cardinal is known nationally and internationally for his signature architectural designs, demonstrated in projects such as his award-winning St. Mary's Church in Red Deer, the Grande Prairie Regional College, the Ponoka Provincial Building, St. Albert Place, the Edmonton Space Sciences Centre, and the Canadian Museum of Civilization, a facility to display and house our national treasures. The firm's work also includes the Kahnawake Tourist Village for the Kahnawake Mohawks in Montreal; the Saskatchewan Indian Federated College in Regina, Saskatchewan; a major hotel complex and Children and Elders' Center for the Oneida Indian Nation of New York near Syracuse, New York; and a master plan for the Cree village of Oujé-Bougoumou, Quebec. The village has earned a United Nation's Award for sustainable development. In 1993 the firm was awarded the design commission for the National Museum of the American Indian on the last remaining site on the Mall in Washington, DC. The firm was a pioneer and world leader in the use of computers in the profession and the business of architecture, and has constantly kept up with technological advancements in this field. We now operate a fully integrated office-wide network, employing the latest CAD technologies in all our work.

Douglas Cardinal is a recipient of the Order of Canada, Canada's highest honour. In 1999 he was awarded the Royal Architectural Institute of Canada Gold Medal, the highest award the profession of architecture in Canada bestows. The firm currently has its head office in Ottawa, where it moved in 1985 to complete the Canadian Museum of Civilization. Douglas Cardinal spoke at several events associated with the

Millennium Conference on Creativity in the Arts and Sciences including the Symposium on Creativity and Innovation in Edmonton, Alberta, and Creativity 2000 in Ottawa. The following are notes he prepared for his presentation at the latter.

Douglas J. Cardinal

We are magical beings, as human beings, because we have this power of creativity. No other beings on this planet have this gift because their patterns of existence are set and just as a deer is always a deer, a bear can only be a bear, a fish only a fish. But, we can recreate ourselves and create the tools to be anything we want, faster than a cheetah, fly higher than a bird, stronger than an elephant; we're not limited. All we have to do is declare our intentions powerfully and keep our word, not operating on reason, but on a total commitment and we make our visions happen. For example, the Wright brothers: The United States government spent $600,000.00 to scientifically prove that machines heavier than air could not possibly fly. However, the Wright brothers, who operated a bicycle shop, had an absolute commitment to fly, and believed that flying was possible. They invented the first flying machines. They weren't scientists, but they were creative people.

Creativity is creating something from nothing. So, entering the creative domain you must be willing to stand on what is known and leap into the vast abyss of the unknown. The known universe has already been created. The creative world is the vast abyss beyond what is known. It is a land of total possibility, a blank sheet of paper that is the land of the eagle, where our true power as a human being "dwells," is found, and is expressed.

The knowledge that we have that is defined I believe is too limited to solve the problems we face today. I believe we must go beyond the created knowledge we have today and be willing to leap into the unknown, to a land where all possibilities can occur.

Einstein developing his theory of relativity made this leap of recreating a whole new way of looking at the universe, although the world around him lived in a universe created by Newton. All of these creative people that have created the vast knowledge we have today took the personal responsibility of expressing this marvelous gift that each one of us has. The reason that most of us do not exercise or use this powerful gift is that we operate from fear. We are terrified of looking bad, of failing, of being ostracized from the group. Fear is unlimited. It is our fear that keeps us small.

We operate from fear and we are so fearful we do not even take responsibility for our lives, much less the powerful gift we have. We give responsibility away to others, to all the institutions that we have created, to people that want to take the power and responsibility from each of us to make vast institutions that control our very lives. All of this is based on our own fear of taking responsibility. Not only do we foster fear within ourselves, we also support all the people and all the institutions around us that magnify the fears within us. Where would the Church and the government be? All of these institutions are based on our not taking responsibility for our lives. All of these groups and individuals that we give our power to have a vested interest in keeping us small.

Ultimately they do not serve the public. These institutions only serve to serve themselves. If we took full responsibility for ourselves, for people we touch with our lives around us, and make a contribution that we're all capable of, we would truly serve our families, our communities, our governments, all the institutions of our society, and ourselves.

Why do we run our lives with fear? Why do we give up responsibility? For the individual power we each possess? Why do we have such a lack of trust in others and in ourselves? I believe it is tied to the fact that we are mortal beings. We're terrified of our own death, of our own demise. There is a sense of helplessness and anger that we are terminal and want to survive at all costs, and in order to function in our lives we deny our own mortality. We have not come to terms with our own death. I believe when you come to terms with your own death and realize you only die once, that it is inevitable, and realize that you are not going to get off the planet alive anyway, so why not concentrate on living to the ultimate and use the precious time that you have. This life is a gift to make a contribution to your own growth and development and those around you. Why be a coward and die a thousand times each time you sacrifice your potential out of fear.

When you walk with death it can become your friend because it will remind you that you have not time to mess about. If you take on your worst enemy, your fearful self, and trust the marvelous gift and power that you have within you then you can walk in trust with yourself and in trust with everyone around you. Thus you have less fear of death than fear of wasting your life, wasting this precious gift of life. Then you will be a fearless warrior, and as a fearless warrior you will gain individual power.

However, to be a knowledgeable being, responsible for your own evolution and that of others around you, you can be limited in your contribution by misusing your power. Power is corruptible and it takes even more warriorship to deal with power than to deal with fear. If you are willing to take on that battle with yourself with a true warrior's stance then you will realize that a

"... we are so fearful we do not even take responsibility for our lives, much less the powerful gift we have ... creativity."

truly powerful person does not need the power of others. Indeed he has the opportunity of empowering others to make a contribution in their lives. Power is something to give away. You do not seek power, instead you seek enlightenment. Power will find you to empower yourself and others to truly make a difference in your lives, and to always walk in trust serving others.

People that seek power and need the power of others are not whole human beings. When you give power to people like Napoleon, Hitler, Mussolini, Franco, or the many tyrants we have found in our society, we create the misuse of power, which tyrannizes every one of us. Just to be a balanced person, Napoleon was an incomplete man who needed all the power of others and of a horse that was 17 hands tall. Anyone needing the power of others is an unbalanced person, an incomplete human being. They are the last people to whom we should be giving our power. Never give away your responsibility and power to an individual or a group.

They can only misuse it. Use your power to empower others in their own lives. But never give your power and responsibility away. You need everything you can to meet your own commitment and bring forth your own contribution, which is your responsibility. You need all the power that you can to defeat the voices within you that can keep you small.

To silence voices so that you can be a luminous body, a strong creative life force that can make a difference. When you regard yourself as more than physical beings, see your self as a powerful light housed in a physical container, then you can truly release your creative energy and bring humanity one step forward in their evolution.

I remember Buckminster Fuller telling us all that his contribution, his creativity only became alive when he saw himself as the water in a throw-away plastic cup; that he was not the plastic cup, rather he was what was in that cup. As soon as he saw his physical body as a throwaway he was able to use that powerful light that was himself to fulfill his creative endeavours.

In my culture freedom has always been paramount. We did not want to be part of agrarian culture although it was far more comfortable to be part of an agrarian society. These agrarian societies meant that you had to give power to an elite group that became tyrants terrorizing each one of its members. This created monolithic structures dictated by a few who equated themselves even to the power of the sun or to an unearthly power.

In the plains we preferred to be hunters and gatherers, which to survive was a much greater challenge. To survive we had to learn to be at one with the earth and all of nature, particularly at one with the animals that gave us life. We had to be at one with the deer, the buffalo, to know their habits. We had to be like them to survive. We could not be above the earth or other creatures.

We had to be at par with a blade of grass. When you have become at par with a blade of grass you can start communicating with all of the living beings. When you have become a deer and know all his patterns he can easily fall into your traps, as though he had offered himself to you. There was reverence — for the animal that gave his life so that you can have yours. This is what you learned when you became a good hunter, a good provider.

When you became trained as a warrior you realized that you had to gain further knowledge of your fellow man. You had to be patternless to be any creature you wished to be. In order to be either a deer or buffalo you change patterns. If you did not change and become patternless you could fall into the traps of your fellow human beings. You had to live outside the realm of your predictable patterned human behaviour. A good warrior was like a shaman who could change himself at will. His battle was to fight tyranny. The tyranny in himself and the tyranny in others, particularly those he had to defend against who may jeopardize his family or his hunting grounds. Indeed, to evolve to be a more knowledgeable person he was to seek tyrants to do battle, to learn and evolve. He regarded the ultimate tyrant as the Great Spirit who could take his life and spirit. It was only the petty tyrant who could take life and physical being because petty tyrants only release the spirit. The small petty tyrants of today can only take material goods. Then the little tiny tyrants make life miserable. In all instances your stance to take on tyranny is to never back down, willing to give life when you make a stand.

Then there are the enlightened spiritual warriors.

This is an even greater challenge because spiritual warriors take on the tyranny within one's self. A spiritual warrior must go through ceremonies to taste death and come back from death. In doing so he learns that it is a tragedy to take the life of another human being for any reason. When you become at one with all living beings you realize that the only creatures on the plains that take the life of their own species or territory is the human animal. No other animal on the plains takes the

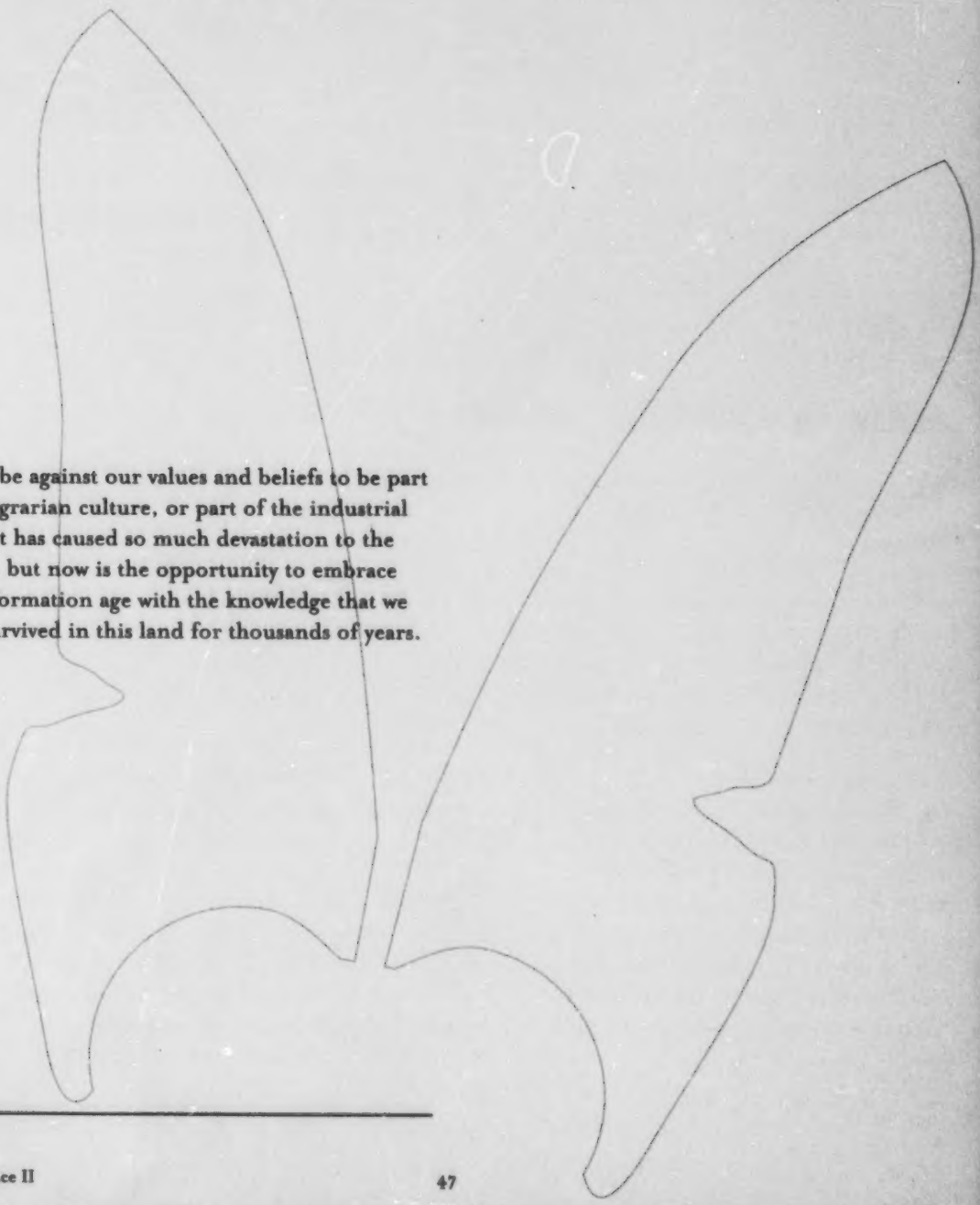
life of its own kind. Wolves bare their throats to their victors, the victors do no kill. Battle between animals on the plains is a sign of strength. Death is usually accidental.

To be a knowledgeable human being walking with his creatures is to be a spiritual warrior. On the plains, spiritual warriors rode to battle with coup sticks with which they would touch a vulnerable part of their adversaries to say: "I can kill you, but I spare you, you are a son, a husband, a father. I will show you my strength so that you will gather in a circle with a sacred pipe. We will agree on our territory, knowing our individual power and strength to protect families, in a peaceful way like other creatures."

Spiritual warriors rode into battle as human beings not human cannibals.

It was putting one's life on the line to trust one's self, to follow the path of enlightenment. But most importantly it was putting your life on the line to completely trust your enemy with your life. Believing that if you projected yourself as a human being that you would create that human being with your enemy, which is the ultimate trust of the goodness in your fellow man. If any person of the tribe killed a spiritual warrior, they were a shameful person.

I believe this traditional path of a man of knowledge who seeks enlightenment is a way of knowledge that is even more important in the world today. It is time to share our knowledge, our traditions and our values with our brothers and sisters, all the members of the human family in this global village.



It may be against our values and beliefs to be part of an agrarian culture, or part of the industrial age that has caused so much devastation to the planet, but now is the opportunity to embrace the information age with the knowledge that we have survived in this land for thousands of years.

Rock Musician and Scientist Says the Truly Creative Are Visual Thinkers Who Begin by Imagining

Information Technology Researcher, Composer, Musician, and Arts Leader Paul Hoffert

Paul Hoffert, a scientist and information technology enthusiast as well as a composer and musician, was a young researcher working in the National Research Council of Canada (NRC) laboratories in Ottawa when his groundbreaking rock band, Lighthouse, was conceived in the late 1960s.

His NRC colleagues at the time included the inventor of the music synthesizer Hugh LeCaine and computer music pioneers such as Ken Pulfer. He had already established a reputation as a music technology innovator at NRC when he was approached by drummer Skip Prokop with the concept of a rock band that included string and jazz-style horn sections. In the early 1970s Lighthouse was the top rock band in Canada winning the Juno award for Group of the Year four years in a row, racking up nine gold and platinum records, and selling out concert halls around the world.

Hoffert is exceptional in the diversity of his interests. His resume includes leadership positions in both the arts and sciences: Executive Director of CulTech Research Centre and a champion of the wired world and new information and telecommunication technologies, Adjunct Professor at York University, Research Professor at Sheridan College, and former Executive Director of Intercom Ontario, the consortium behind the first totally wired, interactive community in the world.

A former Chair of the Ontario Arts Council, Founder of the Canadian Independent Recording Producers Association, President of the Academy of Canadian Cinema and Television, Director of Canada's Performing Rights Organization, and Executive Producer of the Gemini Awards TV broadcasts, Hoffert is clearly a leader in the arts world as well. He has received many honours for his music including the San Francisco Film Festival, Genie, Gemini, Clio, SOCAN Film/TV Composer, and Juno awards both as a member of Lighthouse and for his solo classical music work, th Hoffert Violin

"The truly creative and innovative are not stymied by coming to the end of a road beyond which there is no clear path or destination. They imagine the goal they want to achieve, set it as a destination, and then figure out how to build the appropriate road to reach it. They are not bound by deductive reasoning ..."

Concerto. He is a Member of Canadian Rock & Roll Hall of Fame.

Paul Hoffert gave the keynote address at the Toward a Century of Creativity and Innovation Awards Banquet at the Canadian Museum of Civilization in Hull, Quebec, in February 2000 as part of the Millennium Conferences on Creativity in the Arts and Sciences.

Paul Hoffert

I often have the great pleasure of speaking at a wide variety of engagements, but there is something very special about this one, as it brings me back to my old stomping grounds.

I originally got involved with this great institution by chance. After my studies as a triple major in math, physics, and chemistry at University of Toronto, I followed my muse and formed a rock and roll band. In the late 60's, we performed frequently in Ottawa, and I used to drive by the buildings on Montreal Road, wondering what sort of research took place there. One day, I stopped, walked into the lobby and asked the first person I saw, *"What do you people do here?"*

The retort was, understandably, *"What exactly are you doing here?"* I explained my double background in the arts and sciences and my curiosity about how I might blend those in a research setting. To my surprise and joy, they didn't kick me out. Instead, I was shown a series of labs and introduced to researchers that were devoted to computer graphics, computer music, and acoustics. Within a few months, I had a username and password on one of the NRC computer systems.

During my time here, I had the honour of working with some of the many legendary scientists who have come to the NRC. Bill Buxton, now director of research for Alias Wavefront, was one of my NRC colleagues in those days, as was Ken Pulfer, computer music pioneer and longtime NRC scientist.

They told me about Hugh LeCaine, an eccentric genius at NRC, who spoke fluent Swahili and invented new music machines. Hugh was a fascinating guy who invented the first music

synthesizer (that's right, at the National Research Council). He named it after the ancient musical instrument called the Sackbutt because he had an odd sense of humor and knew that only a few musical literati would make the connection and get the joke.

The original Sackbutt did sound a bit like a medieval instrument and made a rasping sound. It looked, however, like a remnant of the industrial revolution. But it combined electronic processing with tape recordings of real sounds that you could manipulate in a musical manner. Today, rap artists like Puff Daddy use sampling synthesizers in every one of their hit records — descendents of Hugh's original work. Hugh's innovations in the Sackbutt and in other variable-speed multi-track recorders and touch-sensitive keyboards embodied the principles of the NRC, just like the inventions of more orthodox NRC researchers. He was absolutely brilliant and generous with his ideas.

Now the NRC tolerated Hugh tinkering with music because they understood that the arts and sciences have much that connect them. The project I was working on involved music, graphics, and input devices for computers, including piano-like keyboards and a mechanical mouse that predated Apple's mouse by a dozen years. As many great scientists, such as Einstein, have noted, that "Eureka Moment" in which an image is formed in the mind that solves a thorny problem, is shared by great artists and scientists alike.

A painter envisions a finished canvas, a composer "hears" a song, and Einstein imagined time as a fourth dimension. These right-brain exercises illustrate how innovators in the arts and sciences share more with each other than they do with the

left-brain focused engineers who bring their imaginations to commercial success.

The NRC is one of the few organizations that tolerates this linkage of creators — I want to encourage them, and you, to continue to think of the arts and artists as partners in the future that we're inventing together.

Here's a concrete example of how musicians benefited from research at the NRC. When I formed my band in 1969, we faced an acoustics problem that was a formidable obstacle to reaching our audiences. Lighthouse was a rock band with drums, guitars and amps, but also incorporated a jazz horn section and a quartet of strings.

On stage, the violins, viola, and cello could never be properly mixed above the din of the traditional rock instruments. We had many consultations with PA professionals at the time who were unable to offer viable solutions for amplifying our strings without getting the inevitable acoustic feedback.

After bringing some of my string players to NRC and discussing acoustic and electronic issues, they began collaborating with instrument designers who came up with new solid-body stringed instruments whose output was routed to digital signal processors to simulate the sound of natural stringed instruments.

These sounded so good that a spin-off company was formed by Dick Armin, our cellist, who continues to supply these high-quality electronic instruments to some of the world's best string players, including cellist Yo-Yo Ma. The tangible result for us? Our fiddles rocked as loud as the drums!

Earlier, Dr. Carty touched on the concept of genius. Here's what Charles Baudelaire, the French poet from the 1800s, said about genius.

"Genius is no more than childhood recaptured at will, childhood equipped now with man's physical means to express itself, and with the analytical mind that enables it to bring order into the sum of experience..."

Baudelaire is speaking of the genius' openness and naiveté, like those of a child, playing with toys to help illuminate more complex processes. For a genius, creativity isn't a hobby. It isn't something you squeeze between rush hour drives and chauffeuring the kids to hockey practice. The great ones spend countless hours honing their craft, learning to be better scientists, better musicians, and better hockey players.

When we admire genius, we do more than admire talent. Talent is what you are born with — the deck of genetic cards dealt to you by the chance arrangement of your parents' DNA. There's nothing admirable about that. What inspires us is not raw talent, but the application of that talent by dedicated development and nurturing.

Mark Twain once said, *"Thousands of geniuses live and die undiscovered — either by themselves or by others."*

That's especially true in a modest country like ours. Canadians are famous for not wanting to seem too big for their boots.

How many Canadians, for example, know about the century of innovation we have seen in Canada's federal government labs?

How many know about the seminal roles Canadians played in developments ranging from insulin to frozen food? How about the TB vaccine, or the pacemaker, or the Geiger counter, or the flight recorder?

The list goes on — and I've only been talking about federal labs. When you include corporate and university labs, Canadian scientific accomplishments fill the horizon and beyond.

We've all seen those Heritage Minutes honouring Canada's history. If these were dedicated to science, we could fill many Heritage Hours not minutes.

This evening, I am especially honoured and pleased to be part of this banquet under the auspices of the Millennium Conferences on Creativity in the Arts and Sciences. In this respect, I would like to commend the National Research Council, the National Arts Centre, the Canada Council for Arts, and their other partners for pointing out how artificial the division between the arts and sciences communities really is and for encouraging a new, Canadian-led renaissance.

I have believed for many years that the compartmentalization and specialization introduced by the Industrial Revolution has in many ways hampered creativity and innovation. In fact, creative and innovative people in both the arts and science communities have much in common.

I know I touched on this earlier, but for me, this is a fundamental issue that has been pushed aside by the forces of specialization. The truly creative

and innovative are not stymied by coming to the end of a road beyond which there is no clear path or destination. They imagine the goal they want to achieve, set it as a destination, and then figure out how to build the appropriate road to reach it. They are not bound by deductive reasoning, by summing all the known facts.

I am both an artist and a scientist. I know that art touches people in a special emotional way, while sciences stimulates us intellectually. But when the two elements come together, they create something truly wonderful. They make magic.

And this is part of my memory of NRC, which was known as a unique place in North America, if not the world, for respecting the creative and innovative power of arts and sciences. We Canadians have led the world before — through synthetic music, computer animation, and acoustical sciences. There is no reason we can't do it again. There is no reason that Canada cannot be the cradle of a new renaissance that reunites the gifts of artists and scientists.

Happily, we are beginning to take steps to recognize the creative genius in Canada's labs. And tonight, we're recognizing the creative genius at the NRC.

You'll remember Mark Twain saying that sometimes geniuses don't recognize themselves as geniuses. Tonight we will change that. Tonight we are saying, *"Yes, you are important to us. Yes, your work has made a difference. Yes, your work has been noticed."*

We are emerging from one of the most exciting centuries that art and science have ever seen. And as we'll see tonight, the best is still to come.

Tonight, we honour you, the engine of our country's future. What you accomplish in your labs and workplaces is essential to the fabric of the nation.

Arts Leader Talks of the Link Between the Brain and the Creative Mind

Director
Canada Council for the Arts
Shirley L. Thomson

Dr. Thomson is a leading figure in the Canadian arts community.

From 1987 to 1997, she served as Director of the National Gallery of Canada, during which time she oversaw the Gallery's move into its new home, an outstanding series of exhibitions and acquisitions, and its change to Crown Corporation status.

From 1985 to 1987, Dr. Thomson was Secretary-General of the Canadian Commission for UNESCO in which position she also sat on the Senior Management Committee of the Canada Council. From 1982 to 1985, she was Director of the McCord Museum in Montreal. Dr. Thomson has received several honorary doctorates. She was named a "Chevalier des arts et des lettres" by the Government of France, and was made an Officer of the Order of Canada in 1994. Dr. Thomson was named a Fellow of the Canadian Museums Association in 2000.

Dr. Thomson received her Ph.D. in art history from McGill University in 1981, her M.A. in art history from the University of Maryland in 1974, and her B.A. in history from the University of Western Ontario in 1952. Her particular field of interest is 18th-century French art and architecture. She was appointed Director of the Canada Council for the Arts effective January 1, 1998.

She spoke on several occasions in support of the Millennium Conferences initiative as head of one of the principal partners. The following are notes prepared for her remarks to the Creativity 2000 conference as the introduction to the session entitled "The Creative Mind."

Shirley L. Thomson

Good afternoon, ladies and gentlemen, and on behalf of the Canada Council for the Arts, welcome to the third session of Creativity 2000. Mesdames et Messieurs, permettez qu'en mon nom et en celui du Conseil des Arts du Canada, je vous souhaite la bienvenue; ~ cette troisième séance de Creativité 2000, intitulée « Le cerveau et le processus de création ».

Let me launch our discussion with a few lines of 19th-century verse by Emily Dickinson.

They seem to me as good an introduction as any to this complex subject.

The brain is wider than the sky,
For, put them side by side,
The one the other will include
With ease, and you beside....

The brain is just the weight of God,
For lift them, pound for pound,
And they will differ, if they do,
As syllable from sound.

Creativity has much to do with the complex relationship between the brain, the mind, and the world around us.

Time recently published an article on how brain activity is stimulated by music. It quoted Robert Zatorre, a neuroscientist, as saying: *"We tend to think of music as an art or a cultural attribute, but it is a complex human behaviour ... worthy of scientific study."*

I don't think that this is an either/or situation. Music is an art. Its composition and performance

"Creativity has much to do with the complex relationship between the brain, the mind and the world around us."

are directed through the brain and also through external cultural influences. It may sometimes be associated with a brain pathology.

A recent newspaper article asked, "Was Glenn Gould autistic?" Autism is a little understood and very isolating mental condition. Yet almost all people who suffer from autism are musically proficient and a significant number are highly talented, or even prodigies. Glenn Gould may or may not have been autistic. In either case he was certainly a great interpretive artist, and we appreciate the Goldberg Variations more fully because of him.

Brain imaging technologies are now contributing a scientific explanation of some of the things that philosophers, metaphysicians, and artists have been saying for centuries about the way in which we learn and think. Thales of Miletus argued in the 6th-century B.C. that the essential constituent of all things was water.

Since then, Western philosophers, theologians, and scientists have been exploring the idea that all phenomena can be explained as a chain of effects stemming from a primary cause. This is the central theme of the Enlightenment.

This is not the only possible metaphysical model. The ancient Chinese concentrated rather on holistic properties and harmonious relationships, a line of thinking that is perhaps resurgent again in the environmental debate.

But the search for cause-and-effect relationships has proven remarkably productive in the

development of western science. One thing it has done, as Edward O. Wilson[1] has pointed out, is to draw the various branches of science together and demonstrate how they interlock.

Any high school student knows that organisms can be reduced to molecules and understood by the laws of chemistry. And molecules can be reduced to much more elementary particles and understood by the laws of quantum physics.

All the sciences, however, rest upon mathematics, and mathematics derives from human culture, human patterns of thought and belief.

As Northrop Frye pointed out, mathematics *"appears to be a kind of informing or constructive principle in the natural sciences. It continually gives shape and coherence to them without being itself dependent on external proof or evidence."*

"And yet finally the physical or quantitative universe appears to be contained by mathematics.... [There is a] curious similarity in form, for instance, between the units of literature and of mathematics, the metaphor, and the equation."

The conclusion we are led to is that all our knowledge rests ultimately in the human mind's ability to discern pattern.

An Indian mathematician, Ramanujan, born near Madras in 1887 to a poor Brahmin family, possessed one of the most creative minds of the 20th century. His formal mathematical training

consisted of what he learned in high school. His mental training, however, included religion: the massively complex, highly evolved pantheism of the Hindu religion; and many of his mathematical insights came to him through religious meditation: he attributed them to the family goddess.

This intuitive and image-laden process we would normally describe as "artistic."

The point is that Ramanujan thought with great freedom, and that this freedom of speculation was rooted in the rich cultural and spiritual texture of his life.

People with sometimes unnerving frequency ask the question, what use is culture and art?

Well, culture can be looked on as a high-speed evolutionary device, an outrunner of biological natural selection, serving the interests of a complex society by bringing into focus what is important to it.

Culture comprises the life of a society, the totality of its religion, myths, art, technology, sports, and all the other systematic knowledge transmitted across generations. It is complex and diverse.

Yet some simple elements of culture — such as the human smile — are so universal that we can consider them genetically determined.

Art says a great deal about how we understand reality. I want to look briefly at the relationship

between brain function in the act of seeing and the creation of visual art.

To see, the brain must learn to interpret a flow of changing data in order to grasp essential forms — so that it will be able, for example, to recognize a familiar face as the head turns and the light changes.

Neurobiologists have mapped the way it does this. Interestingly, a person born blind and restored to vision as an adult will find it difficult, if not impossible, to learn to see forms.

Art is concerned with seeing forms at a deeper level than the ordinary seeing of appearances.

Schopenhauer said that painting should strive *"to obtain knowledge of an object, not as a particular thing but as a Platonic ideal, that is, the enduring form of this whole species of things."*

Constable wrote in his Discourses: *"The whole beauty and grandeur of art consists ... in being able to get above ... particularities of every kind ... [to] ... make out an abstract idea of their forms more perfect than any one original."*

Artists as different as Michelangelo and Picasso conveyed their vision of enduring form by leaving a degree of ambiguity as a bridge to the imagination of the viewer. Michelangelo, for example, left many of his sculptures in a slightly unfinished state.

Cubism, the most radical departure in Western art since the introduction of perspective, eliminated of point of view in its search for essential

form. It rejected lighting and perspective. It showed figures ambiguously, neither face-on nor in profile. The logical extension of cubism was the rejection of particular objects altogether, and the development of abstraction as, in Mondrian's words, *"the expression of pure reality." "To create pure reality plastically,"* he said, *"it is necessary to reduce natural forms to the constant elements."*

When we perceive an object, as Semir Zeki[2] has pointed out, the brain sees colour first, before form or movement. The straight line is the most basic stimulus to activate a very important category of brain that deals in shape.

A painting such as Barnett Newman's *Voice of Fire* — the most controversial acquisition of the National Gallery during my tenure there as director — stimulates the brain in a specific, immediate, and intense way through the use of strong colours and straight lines.

Voice of Fire, which you can see if you visit the Gallery, is acrylic on canvas. It is a large, tall painting: 5.4 metres high by 2.4 metres wide. On it are painted three vertical columns of colour.

The columns on either side are deep blue with a purplish cast (a combination of prussian blue and ultramarine). The central column is a very warm cadmium red, approaching orange. The contrast is intense. The lines are rigidly straight, although the colours bleed slightly into one another. The texture is flat.

The controversy over its purchase derived, I think, from the fact that abstract expressionism

abruptly rejects romantic concepts that underlie many people's ideas of art. Abstract expressionism is assertive and frankly cerebral. It demands an effort of understanding. It shares with mediaeval art the assumption that meaning may lie beyond, rather than in, appearances.

Unlike mediaeval art, however, modern art does not have recourse to familiar symbols to convey its meanings. It is highly subjective.

To quote the Canadian philosopher Charles Taylor: *"unlike previous conceptions of moral sources in nature and God, these modern views give a crucial place to our own inner powers of constructing or transfiguring or interpreting the world."* This internalization corresponds with modern science's emphasis on the brain as the ultimate source of form and meaning.

Newman adds another twist. *"The present painter is concerned,"* he says of himself, *"with the penetration into the world mystery. His imagination is therefore attempting to dig into metaphysical secrets. To that extent his art is concerned with the sublime. It is a religious art, which through symbols will catch the basic truth of life.... The artist tries to wrest truth from the void."*

Digging into metaphysical secrets is the business of both artist and scientist. As the historian of science Giorgio de Santillana wrote: *"So long as it is alive and not sterile, science will remain a speculum entis [a mirror of being]. It will present what metaphysics did, a symbolic structure*

which is an essential metaphor of being, but is not the only one."

The creative mind is a mind driven to grapple with these profound questions of form and essence that lie beyond ordinary appearances.

Leaving you with that thought, let me tell you something about the distinguished artists and scientists participating this afternoon.

Catherine Richards is a practising artist and an assistant professor at the University of Ottawa's Department of Visual Arts. Many of you may have seen her interactive installation, "Charged Hearts." It was on view at the media launch for this conference.

I have had the pleasure of knowing Catherine for many years. In 1993 she won the Canada Council's Petro-Canada Prize for her virtual reality work, "Spectral Bodies."

In 1996, when she was artist-in-residence at the National Gallery of Canada and I was director there, the Gallery commissioned "Charged Hearts."

A creative work is creative in two senses. The artist has a creative role as the builder or maker. The viewer also has a creative — and active — role in perceiving and understanding the work.

A great deal of Catherine's work explores that mysterious ground between the physicality of the work of art and the physicality of the viewer, between the scientific phenomenon and the

artistic experience. Her current work in progress is about the brain.

"We know we can change heartbeats, and I think we're changing our minds."

Catherine Richards
Visual Artist
Creativity 2000

Dr. Albert J. Aguayo is Director of the Centre for Research in Neuroscience at McGill University. In 1999 he received the Canada Council's prestigious Killam Prize in the Health Sciences. Although most of the Council's prizes are in the arts, the annual Killam Prizes were created in 1981 to honour eminent Canadian scholars and scientists actively engaged in research.

Dr. Aguayo carried out ground-breaking studies at McGill which show that nerve cells in the brain and spinal cord of adult animals retain the ability to regrow and make new functional connections after injury. His research on factors that can promote successful nerve cell growth in the damaged or diseased brain, eye, or spinal cord is important for memory, learning, and other high functions of the mind.

"It seems clear that if we are to have an impact on enhancing the potential for knowledge and creativity of human beings, we have to learn more about how the brain works. I hope also to leave you the idea that by learning about our brains and how to better use them, we may be able to embark in one of the most creative endeavours of all time: understanding ourselves."

"We are moving out of the individual brain and into the collective brain."

"I can tell you that in my own lab, ... it isn't one person who is thinking; it is a group.... It is continuous through new technology.... It is a large community that is thinking and playing with ideas in trying to formulate an answer or design an experiment.

We have a new entity: not only the human brain, but the connected brain.... "

"We are equal, and what makes us different is so little, and yet we have to learn so much about so little because that's what makes us individual and creative."

Dr. Albert Aguayo
Neuroscientist
Creativity 2000

Tedd Robinson was performing at the Canada Dance Festival here in Ottawa last week. I hope that many of you found time to take in his performance and some of the other excellent work presented there.

Quirky originality, humour and pathos, nuance and camp are hallmarks of Tedd's choreography. He achieves a sense of beauty through bizarre juxtapositions, expressing his fascination with both Eastern culture and Western art music. The Council has supported his work extensively.

A choreographer, performer and teacher, he has been commissioned by dance companies and independent artists from coast to coast.

Tedd is based here in Ottawa, where he is the artistic director of *Ten Gates Dancing*, a non-profit organization that promotes the development and performance of contemporary dance works.

Dr. Margaret Boden is an expert on artificial intelligence and the psychology of creativity. Her background includes medical sciences, philosophy and psychology. She was the founding dean of Sussex University's School of Cognitive and Computing Sciences, a pioneering centre for research into intelligence.

As a Professor of Philosophy and Psychology, Dr. Boden lectures widely on artificial intelligence and the human mind. A Fellow of the British Academy, she has published a number of books, among which *Artificial Intelligence and Natural Man* remains a classic.

> *"I don't believe that creativity comes about by magic."*
>
> *"Creativity is part of the natural human world, just as everything else. It isn't in principle beyond the bounds of human understanding, as if it were inspirational from something utterly non-human, or non-cultural."*
>
> **Professor Margaret Boden**
> Creativity 2000

As the 17th-century poet and theologian John Donne said, *"No man is an island, entire of itself. Every man is a piece of the continent, a part of the main."* A vibrant cultural life is a sign of society's health. It also promotes the health of the individual psyche. The creative mind does not develop in a void.

It is fitting that this session on "The Creative Mind" should be sponsored by the **Canadian Institutes of Health Research**, a collaboration of the humanities and the sciences that is working

to forge new links in the promotion of a healthy life.

The ability of the **Canada Council for the Arts** to recognize and support artistic creativity is the basis of its whole funding program. The Council made grants of approximately $111 million to artists and arts organizations last year. Roughly 80 per cent of this funding went to organizations and 20 per cent to individual artists.

In an average year, we receive over 15,000 applications for approximately 120 different competitions. All of these applications are —studied by peer assessment committees of professional artists, who must evaluate the creative potential of each project. To carry out our mandate responsibly, we must understand all that we can about the creative process.

Hence our interest in supporting today's conference. I shall be listening intently as this session carries on.

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[1]Edward O. Wilson is Research Professor and Honorary Curator in Entomology at Harvard University.

[2]Semir Zeki is a professor of Neurobiology and Co-head of the Wellcome Department of Cognitive Neurology at University College, London.

National Science Leader Calls for Support of Arts Education

President
National Research Council Canada
Dr. A.J. Carty

Dr. A.J. Carty has had a rewarding career in science research before being named President of the National Research Council of Canada (NRC).

Dr. Carty spent 27 years at the University of Waterloo where he was successively Professor of Chemistry, Chair of Chemistry, and Dean of Research. Prior to this he spent two years as an assistant professor at Memorial University. Dr. Carty has served on many boards and councils and is currently a member of the Atomic Energy Control Board, the Boards of the Communications Research Centre, the Ottawa–Carleton Research Institute, the Environment Canada R&D Advisory Board, and the Department of National Defence R&D Advisory Board.

Dr. Carty took office as President of the NRC in July 1994. Since then, he has been promoting the vision of NRC as a leader in the development of an innovative, knowledge-based economy through science and technology. He is an active researcher in the field of chemistry and a former President of the Canadian Society for Chemistry. His research interests are in the areas of synthetic chemistry, metal clusters, polynuclear activation of small molecules, and new materials. He has published over 250 papers in research journals, in addition to review articles and book chapters, and has chaired or served on many peer evaluation committees for NSERC and other organizations. He is currently a member of the NSERC Reallocations Committee and the Networks of Centres of Excellence Selection Committee.

Among the numerous honours he has received are the Alcan Award of the Chemical Institute of Canada, the E.W.R. Steacie Award of the Canadian Society for Chemistry, and the Montreal Medal of the Chemical Institute of Canada. He is a Fellow of the Royal Society of Canada and has honorary degrees from the University of Rennes, France, Carleton University, the University of Waterloo, Acadia, and McMaster University.

As President of NRC, he took a very active role in promoting the Millennium Conferences and its themes and establishing new collaborations with the arts and culture communities. As a Canadian science leader, his endorsement of the arts and the importance of arts education brought special credibility to these discussions.

In July 2000, Dr. Carty spoke at the National Art Gallery in Ottawa in the 4th National Symposium on Arts Education. His remarks which reflect upon the Millennium Conferences and Creativity 2000 follow.

Dr. A.J. Carty

I'm very pleased and honoured to open the National Symposium on Arts Education.

Those of you who have come from out of town and perhaps had occasion to wander further down Sussex Drive. About halfway between here and the Governor General's residence, across from the Pearson Building and sandwiched between the British High Commissioner's House and the French Embassy, you come upon an impressive stone building overlooking the river.

This is the National Research Council's original headquarters built in 1932 and still the site where two of our research institutes are located today.

I point this out because, gathered here in this magnificent building, the National Gallery, we're very conscious of Canada's enormous artistic legacy. And down the road, the NRC building reminds us that Canada has a great scientific legacy as well. It's a legacy that the NRC has helped build ever since we were first created in 1916.

In that building, some of Canada's Nobel laureates conducted their research — scientists like Gerhard Herzberg, John Polanyi, Harry Kroto, and Rudolph Marcus. And in that building today, there are young researchers who will be the Nobel laureates of tomorrow.

Out of NRC came some of the science and technology that has created a higher quality of life for Canadians and has made our economy innovative.

Decade after decade, time after time, the NRC has added to Canada's research legacy:

vaccines against meningitis;

electric wheelchairs for quadriplegics;

the first industrial process for the production of magnesium;

the locator beacon that helps rescuers find downed aircraft and the forerunner of the black box;

the heart pacemaker;

the music synthesizer;

synthetic human insulin for diabetics.

These discoveries and inventions that I have just mentioned, as well as a multitude of others, have had a significant impact on society through industrial innovation and wealth generation, health care and technological improvements to our quality of life.

What may not be so well recognized is that many of our innovations have direct application to the arts. In the 1970s, at NRC, researchers invented the algorithms for computer animation and, in collaboration with the National Film Board, created the first animated film *Hunger*. In fact, this milestone in the history of motion pictures was recognized when the two NRC researchers, Marcelli Wein and Nestor Burtnyk, received an Academy Award for their technical creativity in 1998.

This pioneering work at the interface of the Arts & Sciences, while perhaps only a curiosity in the early 70s, has had a tremendous economic impact in the 80s and 90s — the computer animation industry, as illustrated by Steven Speilberg's film *Jurassic Park* and, more recently, *Dinosaur*, is a multi-billion dollars industry, and Canada has continued to be a leader in the field with companies such as ALIAS Wavefront, Soft Image, etc.

Elsewhere at NRC in the 1970s, David Makow, a researcher in the Division of Physics, was pioneering the use of liquid crystals, while his colleague, George Dobrowolski, was exploring the generation and technological applications of thin films. These two researchers began to work together and found ways to use liquid crystals and thin films in painting and sculpture.

They created colours and images that interact with the viewer and the environment. This is an artistic medium for the 21st century and you might be interested in visiting Makow's gallery in Kanata.

> *"Beauty, insight, and invention are augmented by linking the unexpected domains of nature's mysteries."*
>
> **David Makow**
> Scientist, Artist, Inventor

Another medium for the 21st century is virtual reality. NRC has a Virtual Environment Technology Centre in our institute in London, Ontario, and leading edge expertise in virtual reality in our Institute for Information Technology here in Ottawa. Step into the theatre in London, and you could find yourself in the driver's seat of a racecar of the future, or taking a

fantastic voyage into the human heart. All in 3D virtual reality of course. Right now, this technology is used by industrial designers, medical researchers, and urban planners.

It is increasingly being put to work in the film world — remember the terrifying scenes of *The Matrix*, a film in which people live in a totally artificial virtual world because their real environment has been destroyed by atomic war. Most certainly, the 21st century will see a dramatic increase in the use of virtual reality by creative artists and society — to carry us into a fantastic, virtual world and to "see" wonders we can only dream of today.

Another art form of the future involves 3D imaging. In the 1980s, NRC pioneered 3D imaging technology. Today, these synchronized 3D laser scanning systems find a vast array of applications from scanning industrial parts for computer-aided design and manufacturing, to the recording of finger and foot prints for forensic sciences; from reverse engineering of silicon chips to the vision system for the international space station.

Museums, including the Museum of Civilization across the river, use NRC's 3D imaging technology to scan paintings, sculptures, and priceless archeological artifacts. The images are digital. You can download them into your computer, manipulate and look at them from any angle in real colour. You can send them around the world over the Internet. You can, in essence, create a virtual museum or art gallery. For a country as geographically diverse as Canada, this opens some exciting possibilities for Canadians to access our

national collections from anywhere in the country. It also offers great potential for educational purposes.

NRC has also collaborated with the Canadian Conservation Institute and the National Gallery to capture the full three-dimensional, full colour, images of valuable paintings. The Louvre asked us to scan a collection of paintings by Corot and Rembrandt. The object of this was on the one hand to provide a very detailed picture of texture, colour, and material deterioration — on the other, to provide computer reproductions for display which complement or even substitute for the expensive original.

Last year, another high-resolution laser scanner was taken to Florence to participate in the Digital Michelangelo Project. I am sure that Michelangelo never imagined anything like this being done with his art! But just reflect on what an artist, scientist, and engineer such as Leonardo da Vinci could have achieved with such tools at his fingertips.

NRC is also beginning to recognize and contribute to the application of state of the art technologies for arts education. Two weeks ago, I signed a collaboration agreement with Peter Herrndorf, Director General and CEO of the National Arts Centre. We are working together on tele-education initiatives in the arts.

The NAC's Musical Director, Maestro Pinchas Zuckerman, has long been a champion of distance education. He teaches master classes to violin students around the world via the Internet. We are working with him to use broadband

technology so that he can teach these classes in virtual reality. A demonstration of the power of real time interactions of this kind was demonstrated by Maestro Zuckerman at the recent Creativity Conference (which I will tell you about shortly).

I could go on and on about our research, but I think you probably get the point. NRC is at the heart of creativity and innovation in S&T in Canada. Just as this building represents a legacy Canadians have given to the art world, so the NRC building down the street represents the legacy that Canadians have contributed to the world of science and technology.

Last October, when Susan Annis asked me to be the first keynote speaker of your symposium, I wondered, *"Why me? Why would anyone invite a scientist to open a symposium on arts education?"*

There are those who continue to believe that the arts and the sciences represent the opposite ends of a spectrum of human creativity — that if you are drawn to the one, you don't have much interest in the other. But most people who actually are artists or scientists know this is not the case. In fact, there's a very high correlation between artistic and scientific aptitude.

Last year, Canadian researchers examined Einstein's brain. They found that the section of the brain responsible for spatial visioning was uncommonly large. This is the same part of the brain that would be stimulated in a visual artist.

Although best known for his work in theoretical physics, Einstein was also a gifted violinist. In fact, you find many highly qualified people in maths, engineering, and the sciences have musical aptitudes. There's an old joke: what do you get when you bring four Nobel laureates in mathematics together in the same room? Answer: a string quartet.

People in the sciences and in the arts share a similar sense of exploration. They're curious about the world. They want to understand it better — whether the understanding is sought through empirical evidence or through getting in closer touch with the deepest emotions of the human heart. As Albert Einstein expressed it, *"the most beautiful thing we can experience is the mysterious. It is the source of all true art and science."*

People need to express what they have discovered, whether the expression is in the form of an equation or a painting. And I'll say this without any basis in empirical research, but from my own observations — both scientists and artists share a tremendous urge to be creative. And they never lose their sense of childlike wonder.

Einstein once said, *"Imagination is more important than knowledge."* He also pointed out that — *"to raise new questions, new possibilities: to regard old problems from a new angle requires creative imagination and marks a real advance in science."*

Perhaps these words from the *Phantom of the Opera* express it well — and I quote *"close your eyes and surrender to your darkest dreams, purge*

your thoughts of the life you knew before. Close your eyes, let your spirit start to soar — and you'll live as you never lived before."

Creativity is as vital to science as it is to art. This is why the National Research Council this year worked together with the National Arts Centre and the Canada Council of the Arts to stage the Millennium Conference on Creativity in the arts and the sciences. This exciting event, which we called "Creativity 2000," took place just 10 days ago at the NAC.

We filled the NAC's theatre with artists, performers, researchers, and mathematicians. Some were professionals. Some were high school and university students. Through the course of the day, they all heard from, or were entertained by, a vast array of creative personalities. Everyone from award-winning novelists to Nobel laureates in chemistry; from violin virtuosos to researchers in neuroscience.

We heard from Douglas Cardinal, the architect of the Museum of Civilization across the river from here, and the artist, Catherine Richards, who is an outstanding innovator in melding the arts and sciences. We linked up by satellite with people like Sir Arthur C. Clarke, author of *2001: A Space Odyssey*, and Benoît Mandelbrot, the father of fractal geometry.

But I was particularly struck by something Douglas Cardinal said. In his words, *"We are magical beings, as human beings, because we have this power of creativity. Creativity is creating*

something from nothing. So, entering the creative domain you must be willing to stand on what is known and leap into the vast abyss of the unknown. The known universe has already been created.

The creative world is the vast abyss beyond what is known. It is a land of total possibility, a blank sheet of paper that is the land of the eagle, where our true power as a human being 'dwells,' is found, and is expressed."

It was a wonderfully stimulating day. I think we proved conclusively that creative people in both the arts and the sciences have a great deal to offer one another — both in their insights and the products of their imagination.

The audience had an opportunity to raise questions and discuss issues with the guest speakers. One of the most compelling questions came from a high school student. She described her difficulty in choosing a career path. She was very involved in her school drama program, but she was also an honours student in maths and sciences. Her peers and her elders were urging her to make a career choice. They told her that, in this very competitive marketplace, you must choose a niche. Do it quickly! Do it young! Build a career in one field of study. But she didn't want to abandon her love of the theatre. Or her love for mathematics, chemistry, physics, or biology. What was she to do?

She raised this question with a panel that included an architect, a famous chemist, and a movie

writer/director/actor. The consensus was that the important thing was not to lose her passion for the things that interested her. They urged her to maintain the breadth of her interests. And it seems to me that, out of the range of interest and talent of this young woman, something unique may evolve. Something that those urging her to make a choice may not have thought of as a career option.

But for this audience, and this symposium, her dilemma raises interesting issues. Canada needs more men and women who cross traditional boundaries and excel in both arts and sciences. We should discourage the bifurcation between the arts and the sciences that occurs at a relatively early age and positively encourage students to develop significant talents in many disciplines.

Indeed one of the recurring themes of the conference was the importance of early childhood education in stimulating the brain's synapses. This is a powerful theme among educators (and scientists) in Canada, including Dr. Fraser Mustard who chaired a 1999 study on early childhood education for the government of Ontario. A key finding in his report called *The Early Years — Reversing the Real Brain Drain* was that during the early years of a child's life, the billions of cells in the brain are poised to make connections.

This "hard wiring" of the brain occurs through stimulation of specific parts — for example, through reading, through the challenge of learning a foreign language, or the stimulus of an early exposure to science.

Most importantly, neuroscience and human development studies show that this early wiring and sculpting of the brain influences learning, behaviour, and health status throughout life. In fact, scientific research shows that the nurturing a child receives during the first three years of life is critical to the healthy development of the brain.

If I can quote Fraser Mustard here — *"Stimulation and interaction help to activate and 'wire' the connections between brain cells. Experiences during a baby's first days, months, and years affect brain structure which has an impact that lasts a lifetime."*

One of the most studied areas is language, and we are at last beginning to accept that the very young have an incredible ability to pick up new languages — they have the capacity to function truly like sponges — they soak up knowledge. This is an ability that disappears around age 12. I am sure that this city is filled with 50-year-old bureaucrats who can testify to the difficulty of trying to learn a second language as an adult.

But if we can lay down a foundation for languages at a very early age, why not a similar grounding in the sciences and the arts. Each discipline has its own "language" if you will, and introducing the full range of possibilities cannot help but open up an enormous potential for the future.

At our conference last week, I had a very interesting conversation with a colleague from Finland

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who told me that in his country, children at the earliest age are all taught a second language, learn to play a musical instrument, and must study math and science — all before what we would consider grade one. This is a visionary approach that I think Canada would do well to emulate.

Our children are capable of understanding much more than we give them credit for. And at these early ages, the exploration of new ideas, new modes of expression, new languages, can't help but be fun. We should teach our children to enjoy creativity; enjoy exploration, enjoy the physical world around them. Once we have established that early link between learning and fun, we have a foundation on which an individual can build for the rest of his or her life.

Ladies and Gentlemen, I don't think I need to preach to the converted here. I think we share a commitment to early childhood education and to the progressive evolution of our educational system. I also believe, that we all share an enthusiasm for imagination, creativity, innovation, and expression — both for the arts and the sciences.

But in helping you to launch the Fourth National Symposium on Arts Education, I want to assure you that the world of science and technology takes a great interest in the issues you are wrestling with.

We live in an age of convergence. We find convergence everywhere — certainly in science and technology. Computers and telecommunications

technologies converged to create the Internet. At NRC, we're converging technologies as disparate as organic chemistry and electronics.

And it is my prediction that, in the coming years, the worlds of the arts and the sciences will begin to converge as well. Scientific research, the performing arts, the written and visual arts, may seem as far apart as Einstein and Wagner. But let us not forget that in the past some individuals have superbly transcended science and art.

Just think of Leonardo da Vinci, an architect and sculptor of the first order, an artist, a scientist and an engineer — a man whose creative instincts lead him in many directions — and the world reveres his contributions. Why should we not aspire to "free" our children to pursue a diversity of interests, with the sciences and the arts and humanities no longer alternate choices but symbiotic and desirable partners.

At the beginning of a new millennium, we find ourselves in a world where our quality of life is shaped by innovation. We talk about a "knowledge-based economy." But, really, the application of knowledge is much more profound. It affects everything we do: from the quality of our health care to how we entertain ourselves; from how we communicate with one another to how we transact business.

The arts — whether visual or performing, whether the written word or the creation of edifices like this wonderful gallery — have a way of opening the mind. They stimulate the synapses, and make one more receptive to creativity.

"... I want my imagination rekindled. I want to be shown how to look at things in new ways. And I believe my capacity for innovation and creativity in my own discipline will grow as a result."

They send charges down different circuits of the brain, and open new possibilities. As a scientist, I want my imagination rekindled. I want to be shown how to look at things in new ways. And I believe my capacity for innovation and creativity in my own discipline will grow as a result.

That's one good reason for promoting arts education. There are many, many more.

But at a time in our history when Canada is racing to keep at the forefront of knowledge and innovation, I would say that this reason alone should make every policy maker a champion of the arts.

Nobel Laureate Said Embrace Arts and Sciences for Their Own Sakes and Extend Boundaries of Knowledge

Gerhard Herzberg
1904–1999

In March 1999, as plans were being finalized for the beginning of the Millennium Conferences on Creativity in the Arts and Sciences, Dr. Gerhard Herzberg, a Canadian physicist and Nobel laureate passed away. He spent his life in the pursuit of science but also loved and found time for the arts, especially music.

Several events were dedicated to the memory of Dr. Herzberg. These included a performance by the Canadian tenor Ben Heppner with the National Youth Orchestra of Canada and the National Arts Centre Orchestra which was conducted by Mario Bernardi on July 28, 1999. On that occasion, Dr. David Leighton, Chairman of the Board of Trustees of the National Arts Centre said Dr. Herzberg had been "a remarkable Canadian" whose "passion for the arts and sciences is an inspiration to all of us." From October 30 to November 3, 1999, a conference titled "Inspired by Herzberg: Spectroscopy for the Year 2000" was held in Cornwall, Ontario. This was a continuation of conferences that began when Dr. Herzberg was sixty-five and were held every five years. Further, the series of Conferences on Statistics, Science and Public Policy held at Herstmonceux Castle in the United Kingdom which have sought to encourage interaction among disciplines are part of Dr. Herzberg's legacy. In April 2000, the association between that conference series and the Millennium Conference was forged when the latter supported the participation of Miss Angela Hewitt, the renowned Canadian pianist, in a celebration of the new alliance between the arts and sciences.

Although Dr. Gerhard Herzberg did not live to witness the Millennium Conferences on Creativity in the Arts and Sciences,

his spirit was felt throughout, and in many ways, his life exemplified the ideals promoted by the series. Some of his thoughts and the example of his life are captured in the following essay written by his daughter Dr. Agnes M. Herzberg.
Dr. A.M. Herzberg, who attended Creativity 2000 as well as events specifically dedicated to her father's memory, is a Professor in the Department of Mathematics and Statistics at Queen's University.

Dr. Gerhard Herzberg

Dr. Herzberg's advice, his science, his work on behalf of dissidents, his campaigns for the funding of pure science by government, and his sense of fun will always be remembered through the millennium conferences.

Born on Christmas day in 1904 in Hamburg, Germany, Gerhard Herzberg had early on wanted to be an astronomer, but this was impossible as he lacked private means. He was also interested in physics and managed to obtain a private scholarship for the first two years at the Technical University in Darmstadt, and over the following years, he received public funding. After his graduation from the Technical University with a Doctorate in Engineering (Dr.Ing.), he held post-doctorate fellowships at the University of Göttingen and the University of Bristol. He then returned to a position at the Technical University in Darmstadt.

In 1933, Dr. J.W.T. Spinks, a young chemistry professor at the University of Saskatchewan, came to Darmstadt to spend a year working with Dr. Herzberg. Because the political situation in Germany was deteriorating, Dr. Spinks managed with the help of the President of the University of Saskatchewan to obtain a position for Dr. Herzberg at the University; the Carnegie Foundation of New York provided the initial funding. Dr. Herzberg said that his experiences at the University of Saskatchewan and in Saskatoon, from 1935 to 1945, were the best ten years of his life. From that time on, he identified himself as a Canadian.

"A high standard of living is not, as such, a goal worth striving for unless a high standard of living includes a high standard of art, literature, and science ..."

After three years at the Yerkes Observatory of the University of Chicago in Williams' Bay, Wisconsin, Dr. Herzberg returned to Canada in 1948, to the National Research Council of Canada. He was appointed Director of the Division of Physics in 1949 and retired from that position in 1969. He remained at the Council as Distinguished Research Scientist and continued his research for almost the next thirty years until illness made this impossible.

Dr. Herzberg was awarded many honours, including the Nobel Prize for Chemistry in 1971. He did not forget the University of Saskatchewan:

"It is obvious that the work that has earned me the Nobel Prize was not done without a great deal of help. First of all, while at the University of Saskatchewan, I had the full and understanding support of successive Presidents and of the Faculty of the University who, under very stringent conditions, did their utmost to make it possible for me to proceed with my scientific work."

Before taking on the position of Director of Physics, he was told that his *"main administrative function would be to find first-class people for the positions that were open and let them use their own judgement in selecting their research projects rather than try to direct them."*

Dr. Herzberg believed that advances in science stem from research done when individuals are given free rein and not restricted by the policy decisions of government agencies or committees. Demonstrating his belief that administrators are

meant to support science, Dr. Herzberg wore a white laboratory coat even when confined to his desk. The key to scientific success and technological advance, he felt, was in the laboratory, and not in the office or committee room.

He also defended publicly his conviction that a society should maintain a high standard of progress in science and the arts; survival should not be society's only goal. He felt that all citizens needed to consider *"the works of art, literature, and basic science as not merely the icing on the cake but as the essence of human existence."*

Dr. Herzberg worried about the divide between the arts and sciences. In a paper, "Remarks on the Boundaries of Knowledge," he wrote:

"The limitations to the advance of knowledge that are introduced by the limited extent of our memory (and I realize that there are many other reasons) are illustrated by the sharp schism between literary intellectuals on the one hand and natural scientists on the other, so eloquently described by C.P. Snow in his little book The Two Cultures and the Scientific Revolution. *Of course, this schism really goes much further, as was recognized by C.P. Snow; even among scientists of one discipline there is considerable lack of understanding of the work in other disciplines. While much of this schism is caused by the limitations of the average intellect, the division is further fostered to a considerable degree by our educational system, which in my opinion gives far too much choice to students of our high schools."*

He went on,

"... let us develop a cultural climate which believes that human excellence is a good thing in itself, a climate in which all members of society can rejoice and delight in the things that the small number of exceptional members is able to do, without asking what use they have for survival. ... Without that, to quote C.P. Snow, 'some of the major hopes, the major glories of the human race will rapidly disappear.'

... the striving for excellence in order to increase our cultural heritage and to extend the frontiers of knowledge is the most important aim of mankind. There may be more urgent things to be done in connection with our survival. But we must not let these necessities detract us entirely from our devotion to the striving for knowledge for its own sake, to the aim of understanding man and his world."

In summary, the words Dr. Herzberg used some time ago are appropriate not only for Canada, but for all countries:

"A high standard of living is not, as such, a goal worth striving for unless a high standard of living includes a high standard of art, literature, and science.

... If Canada is to be economically prosperous without at the same time supporting the arts and sciences for their own sakes, it will not reach the level of a great nation."

Call for a National Forum on Creativity and Innovation

In late May 2000, the Symposium on Creativity and Innovation in the Arts and Sciences was held as a featured part of the 2000 Congress of the Social Sciences and Humanities at the University of Alberta in Edmonton in association with the Millennium Conferences.

A compilation of suggestions made at the symposium has been prepared as a special report for the Honourable Herb Gray, P.C., M.P., Deputy Prime Minister, and Minister responsible for the Millennium Bureau of Canada. This report constitutes a legacy of Canada's national Millennium celebrations from the partners, the Humanities and Social Sciences Federation of Canada (HSSFC), the Social Sciences and Humanities Research Council (SSHRC), the National Research Council (NRC), and the University of Alberta. (Appendix I).

The chair has called for a National Forum or Task Force on Creativity, Inventiveness, and Innovation *"to explore and identify ways in which new and original ideas can be encouraged and developed across the full spectrum of the arts, sciences, medicine, social sciences, business, industry, and technology in Canada for the use and benefit of all Canadians."*

D.M.R. Bentley
Professor
Department of English
University of Western Ontario
and Chair of the Symposium
on Creativity and Innovation in
the Arts and Sciences